TRANSACTIONS

OF

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS

VOL. VIII.

EIGHTH ANNUAL MEETING
NEW YORK, JANUARY 21-23, 1902

SUMMER MEETING
ATLANTIC CITY, N. J., JUNE 16, 1902

PUBLISHED BY THE SOCIETY
AT THE OFFICE OF THE SECRETARY
NEW YORK CITY

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CONTENTS.

XCII.

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS.

EIGHTH ANNUAL MEETING

New York City, January 21, 22, 23, 1902.

PROCEEDINGS.

First Session.

The Eighth Annual Meeting of the Society was held in the hall of the American Society of Mechanical Engineers, No. 12 West Thirty-first Street, New York City, on January 21, 22 and 23, 1902.

The meeting was called to order by the president, Prof. J. H. Kinealy, of St. Louis, Mo., at 2.30 P.M., on Tuesday, January 21.

The roll was called by secretary Mackay.

On motion the reading of the minutes was dispensed with. The President then read an address as follows:

PRESIDENT'S ADDRESS.

Members of the American Society of Heating and Ventilating Engineers:—

It is my privilege as well as my duty to address you to-day upon matters of interest to the Society. I do not propose to confine my remarks to those things pertaining to the present condition as to members or money of our Society, because of these you will learn from the reports of the secretary and treasurer; and as to what work has been done during the past year by the committees, you will learn from the reports of

their chairmen. I propose to speak to you to-day of the heating and ventilating engineer and his work.

During the first half of the nineteenth century, engineers were classed under two heads: military engineers and civil engineers. The military engineers were those who did work of an engineering character in connection with military operations. They built forts, military roads, bridges and other structures whose primary use was for military operations, for facilitating offensive and defensive movements. Military engineers were, as a rule, soldiers first and engineers second. Under the head of civil engineers were classed all those men who had to do with engineering work which did not pertain to military operations. All engineering work of whatever character which was civil and not military, was done by the civil engineers.

Towards the middle of the nineteenth century, the civil engineering work became so varied and diversified that engineers other than military engineers were classed under two heads; namely, civil and mechanical engineers. Civil engineers were those who built structures which were at rest, structures such as bridges, buildings, viaducts, sewage systems, water works, etc. Mechanical engineers were those who built machines—objects which were to be for the most part in motion. They built steam engines, machinery for factories, locomotives, steamships, etc. The civil engineer had to do largely with that part of mechanics called statics, while the mechanical engineer had to do largely with that part called dynamics. Later, each of these large branches, civil and mechanical engineering, was subdivided into a number of smaller divisions, and the engineer who did work pertaining to one of the smaller divisions was termed an electrical engigeer, a sanitary engineer, a steam engineer, a bridge engineer, or a structural engineer, depending upon the branch of work in which he was engaged.

Among the latest of the engineers to acquire a distinct title was the heating and ventilating engineer. The heating and ventilating engineer does work which is largely that of the mechanical engineer. It is his duty to supply the occupants of buildings with heat to keep their bodies warm during cold weather, and with fresh air for the preservation of their life

and health. The heating engineer should be a mechanical engineer. He should know about engines, boilers, steam piping, shafting and other things about which the mechanical engineer must know; and in addition he must have, to a certain degree, that kind of knowledge which a physician has, in order to enable him to determine what are the effects of too high or too low a temperature upon the human body, what are the effects of too great or too small an amount of moisture in the air breathed by human beings, and what are the effects of impure air upon the health and well-being of the occupants of rooms. He must know these things not only from the standpoint of the physician, but also from the standpoint of the engineer, from the standpoint of one who, knowing the good or bad effects of certain things, is capable of devising means by which the bad effects may be eliminated and only the good effects preserved. He must know these things in such a way that he can appear before a board consisting entirely of laymen or of laymen and physicians, and be able to tell them what things are necessary for the proper heating and ventilating of a structure in order that the persons occupying this structure may live in it with comfort and convenience, and without detriment to their health. He must be able to give reasons for this thing and for that thing; he must be able to overcome the ignorance and prejudice of the unlearned; and further, he must be able to point out how to obtain those things which he says are necessary to the comfort and health of the occupants. When telling what is necessary, he must act the part of the physician; and when telling how to obtain these things, he must act the part of the engineer. There are to-day, many physicians who either through old fogyism or lack of broad training do not know what they should, or at least do not advocate what should be advocated for the proper ventilating and heating of schools, hospitals and other buildings in which large numbers of people are to be congregated for a considerable period of time. These physicians, the heating and ventilating engineer must be able to meet on the plane of a physician; he must be able to talk intelligently and in such a way that the physician will understand; and he must be able to convince the physician that he knows what he is talking about and is right in what he says, or he must at least

be able to convince those who have the deciding voice in the question of how a building shall be heated and ventilated. Having convinced the physician or others, as to what shall be done, the heating and ventilating engineer must then become a mechanical engineer and must be able to discuss with intelligence and force, the proper and most economical method of generating heat by the combustion of fuel, of transmitting this heat from the point of generation to the point of use, and the method or means by which this heat is to be made available for the heating of the building; he must be familiar with the operation of engines and electrical machinery, in order that he may choose the proper motor for running the fan or other device for supplying air to the building to be ventilated; and he must know the laws which govern the flow of air and steam through pipes and flues.

It may seem that I am requiring in my assertions a large amount of knowledge for the heating and ventilating engineer, an amount of knowledge which few of us can claim to have. While I think that this is true and while I think that there are few of us who know as much as, in my opinion, a heating and ventilating engineer ought to know, still I do not think that I am setting the standard of knowledge at all too high; nor do I think that the standard I am setting is one which, in a few years, will not be reached by all heating and ventilating engineers who will stand in the first rank of their profession.

It must be remembered that the heating and ventilating engineer is a distinct outcome of a long evolution. The first men to study and agitate the question of heating and ventilating, were hardly engineers; they were physicians. They knew what ought to be supplied to buildings in the way of warmth and air, but they did not know how best to attain the results which they sought. These men gave to others, to men who were engineers, simply their ideas as to what should be obtained and left to those other men the work of devising means for obtaining them. These physicians, as I have said before, were in no sense engineers, and the engineers who carried out the ideas of these physicians were in no sense physicians. The result was that there were two classes of men working together: the one who knew only what was desirable and what should be striven for in the way of heating and venti-

lating; the other who knew nothing of heating and ventilating from the physician's standpoint, who knew only of engines, boilers and machinery and who simply carried out the dictates of the first class. Each of these classes was mutually benefited by its contact with the other. The physician acquired a knowledge of what could be done from the engineer, and the engineer acquired a knowledge of what should be done from the physician. As a result of this intercourse between the two classes, there has sprung up the class of men whom we now call heating and ventilating engineers. And to-day we have in this country, many men who know what ought to be done, and who also know how to attain the results desired—men who are learned in that they have knowledge, and who are wise in that they know how to use that knowledge. These men have studied heating and ventilating from the standpoint of the physician and also from the standpoint of the engineer.

To-day, physicians are working upon the problems met with in heating and ventilating, and are attempting to solve those which are solely problems of physiology or hygiene, and engineers and physicists are working upon those problems which belong to the domain of engineering and physics. The heating and ventilating engineers are by a process of natural selection and evolution becoming divided into three classes. The first class comprises those men who are working, experimenting and studying the experiments of others, to determine what results should be obtained in a properly heated and ventilated building. They are men who, while engineers, are studying the works of physicians and are studying with physicians to determine the effects of high temperatures upon human beings, the effects of low temperatures, the effects of moisture in air, the degree of impurity which results from the breathing of air by human beings, and other questions which, while they have been studied for many years, are still unanswered and about which there is yet much to be learned. To this class belong also the physicians, physicists and scientists who are studying heating and ventilating almost as an abstract science. To the men of this class is due the progress of heating and ventilating as a science.

The second class consists of those men who partake in their

make-up and training more of the engineer than the physician or the physicist and who consider only the means to be used in carrying out the wishes of the first class, who devise apparatus for heating buildings and apparatus for ventilating buildings, men to whom we must look for those improvements in heating and ventilating devices which will enable us to properly and economically heat and ventilate buildings. To this class belong those who design, construct, and erect heating and ventilating plants, and also those men who invent new systems and new apparatus for heating and ventilating. To the men of this class is due the progress of heating and ventilating as an art.

The third class consists of those men who partake of the nature of the men of both the first and second class; those men who on account of their training and scientific knowledge are able to judge of the questions of heating and ventilating largely from the standpoint of the physician and physicist, but who also, on account of their practical engineering knowledge and training, are able to judge of the devices used in the art of heating and ventilating. To this third class belong largely those men who derive the rules, formulas and tables upon which all or nearly all calculations pertaining to heating and ventilating work are based. The men of this class are the connecting link between the men of the first and second classes, and are helpful to both. They collaborate, compare, and study the work of the men of the first class, and having separated the wheat from the chaff transmit the results of their labors to the men of the second class. Through their work the science is reduced to an art, and the art to a science.

In this country there are few men, or I should say few heating and ventilating engineers, who are making experiments or working with a view to determine what results should be attained in a well-heated and ventilated building. Nearly all of the heating and ventilating engineers of this country are working towards means of attaining those results which physicians or engineers in other countries tell us should be attained in well-ventilated buildings. In other words, there are few in this country, few even of the members of the American Society of Heating and Ventilating Engineers who belong to what I have termed the first class of heating and ventilating engineers.

Nearly all of us belong to the second class. That is, nearly all of us are concerned in devising means for carrying out work, for heating and ventilating buildings as others tell us they should be heated and ventilated. There are a few who make experiments and there are fewer still who use their own experiments or the experiments of others, in order to formulate rules or equations to be used in designing and laying out heating and ventilating plants. In Germany, I think it may be said, there are more men who concern themselves with what results should be attained in a well-heated and ventilated building than there are men who concern themselves with the devices required to attain these ends. That is, there are more men who are experimenting and working to find out what should be attained than there are men who are working and experimenting in order to determine how to attain these ends. In this country, the heating and ventilating engineers are hardly scientific enough. They are scientific only in the adaptation of means to an end. They are not scientific in their search for the end. In this country our engineers are too practical, they lean more towards the devices used to attain the end than towards the end itself. But it has been this trait in the heating and ventilating engineer of the United States, which has enabled us to make such rapid strides in the art and to forge so far ahead of other countries in the attainment of well-heated and ventilated buildings. In Germany I think that they are too scientific in their search for the end to be attained and not practical enough in their use of machinery or devices to attain this end: too much time is given to the science and not enough to the art. In England I believe that the engineers are behind the engineers of either this country or Germany. So far as I can gather, they seem to be followers only. They do not seem to be making experiments to determine either what results should be attained in a well-heated and ventilated building, or experiments to determine how best to attain those results which should be attained. There are few of their engineers who are prominent in either the science or the art of heating and ventilating.

As this Society was the first society of heating and ventilating engineers in the world, and it has been followed by the formation of societies of heating and ventilating engineers in

Germany and in England, so I think the work of the heating and ventilating engineers in this country stands first and ahead of the work of the heating and ventilating engineers of any country. And while we may pride ourselves upon this fact —and fact I think it is—we must not forget that in order to hold this powerful position, we must work, and work not alone in one line. We must work in the science as well as the art of heating and ventilating. We must experiment and determine what results should be obtained in well-heated and ventilated buildings, and then we must continue our work to determine how best to attain those results. We must have engineers or experimenters who will determine the effects of temperatures, the effects of humidity, and the effects of impure air upon the human system; we must have engineers who will tell us how to improve the apparatus which we now use, how to attain the best results most economically and satisfactorily; and, further, we must have those men who will devote their time to the study of experiments in all branches of the science and the art, and to the working up of the experiments in order that they may formulate the results of these experiments and give them to us in the form of rules or equations which can be understood and used by all. Without the science, there will be but little progress in the art, and without the art the science is of little value. Each is dependent upon the other, and the more in harmony they are advanced, the more rapid will be the progress in heating and ventilating, and the greater will be the benefit derived by the human race.

The American Society of Heating and Ventilating Engineers is fortunate in being able to class among its members men who belong to the three classes of heating and ventilating engineers of which I have spoken before. The Transactions of this Society has been for several years in the past, and will continue to be in the future, a repository of the results and information obtained through the work of its members. And it is to be hoped that the Society, will grow and continue in its place of usefulness, and that it will also broaden its sphere of work by inducing all of the many men who are working in some way or other in connection with the science and art of heating and ventilating in this country to become members of it and to put on record in its Transactions the results of their experience and

work. No man in this country is too big for the society, and the Society is not too big for any reputable man who can aid in the least the advancement of the science and art of heating and ventilating.

The secretary then read the names of those who were elected to membership in the Society since the last meeting, as follows:

NEWLY ELECTED MEMBERS ANNOUNCED AT ANNUAL MEETING, JANUARY, 1902.

James Curran,	New York,	Member
P. S. Hudson,	Chicago, Ill.,	"
William C. Dean,	Ithaca, N. Y.	"
H. A. Kries,	Baltimore, Md.,	"
E. E. Palmer,	Albany, N. Y.,	"
H. L. Anness,	East Orange, N. J.	"
William G. McPherson,	Portland, Ore.,	"
Henry Hamelle,	Paris, France,	"
Wilhelm Dahlgren,	Stockholm, Sweden	"
H. A. Smith,	New York,	"
William R. Stockwell,	New York,	Junior.

The secretary then read his annual report, as follows :

SECRETARY'S REPORT.

New York, January 21, 1902.

The American Society of Heating and Ventilating Engineers.

Gentlemen: Your secretary would report an increase in membership during the past year. At the last annual meeting our Society was composed of 119 members, one honorary member, seven associates and four juniors; or a total membership of all grades of 131. During the year we have added seventeen members, one associate and one junior to our rolls, and one associate has been advanced to full membership, two associates have resigned, three members and a junior have been dropped from the rolls for non-payment of dues and one of our members, Mr. Charles F. Tay, of San Francisco, Cal., died on February 8, 1901. Our present membership is 133 members, one honorary member, five associates and four juniors; or a total of 143 members of all grades, a net increase of twelve during the past year. In addition to this we have received

seven additional applications for the different grades of membership, which will be acted on and voted on as soon as a ballot can be prepared after the annual meeting.

Financially, we may be said to be in about the same condition as at the last annual meeting, when we had a balance on hand of $85.93, a balance owing from members for dues of $395.00 and a total indebtedness of $432.82.

We have received from all sources during the past year. $1,619.84, this with the balance on hand, making the total amount available $1,705.77.

The expenditures have been $1,625.24, leaving a balance in the hands of the treasurer of $80.53, with a balance of $300 owing from members for dues.

We owe J. J. Little & Co., $100 balance on 1900 Proceedings, and there is a balance of $288.09 due the secretary for expenditures, making a total indebtedness of $388.09, so that if all outstanding dues were paid, there would be a deficit of $7.56. The four members dropped from the rolls owed the Society $30 each for dues, or $120; so that had all members met their obligations, there would have been a balance of $112.44 on hand after paying all indebtedness, showing that the original or present rate of dues, $10 per annum, with an average membership of 150, when promptly paid, is sufficient to meet our present expenditures.

The secretary's expenses for the year, including stenographer, clerk hire, postage, rent of post-office box, expenses in connection with the summer meeting, expressage, etc., amounted to $388.33.

The 1901 Proceedings have been edited and placed in the printer's hands and will be forwarded to the members as soon as possible after this meeting.

The Proceedings of the Society are sent free to thirty-four of the leading colleges, engineering and architectural societies.

The Society held a successful summer meeting in Chicago, July 12th and 13th, 1901. The papers presented, being received too late to be printed, were read from the original manuscript.

The papers to be presented at this meeting, while received late, have all been printed and forwarded to the members.

Respectfully submitted,

W. M. Mackay, Secretary.

The report of the treasurer was then read by the secretary.

TREASURER'S REPORT.

Gentlemen: Your treasurer begs to submit the following report:

Balance on hand Jan. 21, 1901		85 93	
Cash received since Jan. 21, 1901:			
Pin badges	$5 50		
Proceedings	29 84		
Initiation fees	340 00		
Dues	1,244 50	1,619 84	
			$1,705 77
Treasurer collections, stamps, etc	5 32		
W. N. Jennings, 1899 Proceedings	300 00		
Secretary, 1900 account	132 82		
Secretary, 1901 account	100 24		
Programmes, ballot, etc	78 85		
Am. Soc. Mec. Engineers rooms	65 00		
Bormay & Co., cuts	60 68		
R. W. Ryan, stenographer	171 50		
J. H. Kinealy, check sent in error	10 00		
J. J. Little & Co., advance papers	54 50		
J. J. Little & Co., 1900 Proceedings	437 66		
Chapman & Bloomer, certificates	6 00		
Chapman & Bloomer, letter heads, etc	13 00		
Dinner committee	5 32		
Editing 1900 Proceedings	100 00		
Lantern & Attendant, Chicago meeting	15 00		
Henry B. King, stenographer	54 35		
Fidelity & Casualty Co., Treas. Bond	15 00		1,625 24
Balance in Washington Trust Co.			$80 53

Respectfully submitted,

JUDSON A. GOODRICH, Treasurer.

The report of the board of governors was then read by Mr. Snyder.

REPORT OF BOARD OF GOVERNORS.

Annual Meeting, 1902.

Gentlemen: Your board of governors met and organized January 24, 1901, appointing a committee on finance, membership and publication, and electing an executive committee of New York City members.

The various committees have given careful attention to their duties, and the board has held five meetings during the year.

We are able to report a substantial increase in membership, while financially the condition of the Society is about the same as at our last annual meeting.

There are still several hundred dollars owing from the members for back dues and we would urge a prompt payment of this and the annual dues which will become due on February 1, 1902.

Your board have delayed publishing the 1901 Proceedings, feeling that we should not increase our indebtedness until the balance due on the 1900 Proceedings was paid. We are pleased to report that the treasurer has now almost sufficient funds on hand to pay this balance, which has been reduced to $100. The 1901 Proceedings have been edited and placed in the printer's hands and will be forwarded to the members as soon as completed.

A revised list of members, together with the Constitution and By-laws, will be published and forwarded to the members after this meeting.

We hope that the incoming board of governors may be placed in a position financially to enable them to have this year's Procedings printed and forwarded to the members before the end of the year.

While the majority of the papers to be presented at this meeting were received rather late to be edited, cuts prepared, etc., they have all been printed and forwarded to the members.

Acting on the vote of the Society at the last annual meeting, your board arranged for a summer meeting at the Victoria Hotel, Chicago, Ill., July 12 and 13, 1901, at which a number of our members and a large number of guests evinced a marked interest in the entire proceedings.

As the papers presented at the summer meeting were not received in time to be printed, they were read from manuscript, and will appear in the Annual Proceedings.

Respectfully submitted,

J. H. KINEALY, Chairman.
WILLIAM KENT, Vice-Chairman.
R. C. CARPENTER,
R. P. BOLTON,
JOHN GORMLY,
C. B. J. SNYDER,
W. M. MACKAY, Secretary.

The secretary then read the report of the standing committee on "Compulsory Legislation."

REPORT OF COMMITTEE ON COMPULSORY LEGISLATION.

Annual Meeting, 1902.

The American Society of Heating and Ventilating Engineers.

Gentlemen: Your committee would report that efforts have been made during the past year to secure legislation to compel proper ventilation of public buildings and schoolhouses in the states of Pennsylvania, New Jersey, Maryland, Michigan, Illinois and New York.

Bills are now before the legislature in Illinois and Maryland.

In New York State, with the able assistance of Mr. H. A. Gouge, the accompanying bill, which was approved by the New York State Board of Health, was presented in the assembly by Mr. Henry, a member from New York City and chairman of the health committee, last March, and while the bill was acceptable and we received every encouragement that it would be passed, we regret to say that, like all former bills presented by the Society in this State, it was finally defeated, but is being presented again this year, and we are encouraged to hope that it may be adopted.

Respectfully submitted,

WILLIAM M. MACKAY, Chairman,
T. B. CRYER,
A. HARVEY,
T. J. WATERS,
B. H. CARPENTER.

The bill for New York State referred to in the above report is as follows:

STATE OF NEW YORK.

No. 1748. Int. 1295.

IN ASSEMBLY.

March 12, 1901.

Introduced by Mr. Henry—(by request)—read once and referred to the committee on public health.

AN ACT

To secure proper sanitary conditions and proper ventilation in public buildings and schoolhouses.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. Every public building and every schoolhouse shall be kept in a cleanly state and free from effluvia arising from any drain, privy, or other nuisance, and shall be provided with a sufficient number of proper water-closets, earth-closets or privies for the reasonable use of persons admitted to such building or attending such schoolhouse.

§ 2. Every public building and every schoolhouse shall be ventilated in such a manner that the quantity of foul or vitiated air exhausted or removed shall be not less than fifteen cubic feet per minute for each person, and the quantity of fresh air admitted shall not be less than fifteen cubic feet per minute for each person whom such public building or schoolhouse is constructed to accommodate. The provisions of this section and each preceding section shall be enforced in each city, village, town or county by the board of health thereof. It is made the duty of such boards of health, within six months from and after the passage of this act, to inspect all the buildings then in use within the meaning of this act, and thereafter to inspect all buildings which shall be applied to the uses herein recited. It is further made the duty of any such board of health, on application in writing of any one interested, for an inspection of any public building or schoolhouse, to make such inspection within a reasonable time, not exceeding one month

after the receipt of such application in writing, provided that such board of health in its discretion may refuse to inspect any public building or schoolhouse which appears from its records to have been so inspected within the six months next preceding. And include the determination of the quantities of air actually removed and introduced and their sufficiency under this act.

§ 3. Whenever it shall appear to the proper board of health, upon inspection of any public building or schoolhouse, that the sanitary provisions or means of ventilation thereof are insufficient to conform to the requirements of this act, and that the same can be made sufficient without unreasonable expense, such board of health shall issue a written order to the proper person or authority, directing such sanitary provisions or means of ventilation to be supplied, and the same shall thereupon be supplied by the public authority, corporation, or person having charge of, owning, or leasing such public building or schoolhouse.

§ 4. Any public officer, corporation or person neglecting for six months after the receipt of a written order from the proper board of health, as hereinbefore provided, to supply the sanitary provisions or means of ventilation required thereby, shall be punished by a fine of one hundred dollars. If any board of school trustees shall for a like period of time fail to comply with the requirements of such written order from the proper board of health, each member of such board shall be punished by a fine of one hundred dollars, provided, however, that in any case wherein the board of health is satisfied that such failure to comply is unavoidable, and the public officer, corporation, or person responsible, is in good faith preparing to comply with such order, this penalty shall be remitted.

§ 5. Whenever it shall appear to the proper board of health that a written order, given under the fourth section hereof has not been obeyed within one month after its delivery to the proper person or authority, such board of health shall have power, and it is hereby made its duty, to prohibit the use of such public building or schoolhouse until the requirements of such order are complied with, it being provided that such action shall not be taken by such board of health if it is satisfied that the failure to comply is unavoidable and that the trus-

tees, public officer, corporation, or person responsible is in good faith preparing to comply with the requirements of the order.

§ 6. The expression "public building" used in this act shall include any public building or premises used as a place of entertainment, instruction, resort, or assemblage. The expression "schoolhouse" shall mean any public building or premises in which instruction is afforded to not less than ten pupils at a time.

§ 7. This act shall take effect immediately.

The president asked if any member cared to discuss the report, but no discussion was offered.

The President: The next report is Uniform Contracts and Specifications. Mr. McKiever.

Mr. McKiever: The committee had hoped to have a report ready to report at this meeting, but owing to the illness of the other New York member of the committee, we would ask that the report be laid over until some future session before this meeting is ended.

We have decided not to take up the question of uniform specifications, but to take up the question of uniform contract, and we feel that we have drafted a contract that will meet with general approval but some criticism. If we succeed in invoking a great amount of criticism, we feel that we have fulfilled the purpose for which we have been appointed, because it will no doubt provoke discussion, and that is what we are after.

We have been considerably handicapped by the fact that some of the committee are not residents of New York, and therefore time has been lost in correspondence. One of the members of the committee, Mr. Bolton, is ill, and expects to be confined to his room for two or three days. If we do not succeed in getting him here to-morrow, we will have a conference with the balance of the members of the committee and present our report.

The President: We will take what Mr. McKiever has said as a verbal report of progress.

The next committee to report is the Committee on Standards. The members of the society at its annual meeting in 1901, by vote, continued the Committee on Standards that was in exist-

ence during the year 1900, thereby taking from the president the power to appoint a new committee. The same vote required that the secretary should have printed and distributed the report which the Committee on Standards presented in 1900. That has been done, and the report has been put down on the programme for discussion to-morrow afternoon.

Are there any reports from special committees?

Mr. Jellett read the following report:

REPORT OF THE SPECIAL COMMITTEE TO ARRANGE WITH THE INSTITUTE OF ARCHITECTS IN THE MATTER OF PROFESSIONAL CHARGES.

To the American Society of Heating and Ventilating Engineers:

Gentlemen: Your committee reported at the last annual meeting, the result of their conference with the committee of architects during the preceding year, in reference to an agreement upon a definite charge for engineers' services covering the installation of steam plants, heating, ventilating, etc.

At the convention of the American Institute of Architects, held in Washington, December 12 to 15, 1900, the committee of the Institute of Architects, who had been in conference with our committee, made the following report and recommendations:

"Report of Committee of the American Institute of Architects, in conference with a committee of the American Society of Heating and Ventilating Engineers.

"To the Convention of the American Institute of Architects,
Held in Washington, December 12 to 15, 1900.

"Your committee reports that in conference with a committee appointed by the American Society of Heating and Ventilating Engineers, and in consultation with sanitary, electrical, mechanical and other experts, and with architects representing all sections of the country, and all classes of practitioners, there has been practical unanimity of opinion on the following points—

"(1) That in the design, construction and equipment of modern buildings the problems of sanitary, electrical and mechan-

ical engineering, of heating and ventilation, of structural work and foundations are much more complicated and their solution much more expensive than was the case when the present schedule of charges of the Institute was first adopted, at which time, to use words taken from a recent convention report, 'The erection of a building could safely be left to a competent carpenter's foreman, or to a master mason.' And this development has in many cases rendered necessary the employment of experts, either permanently on the staff of the architect, or by engagement for a specific work.

"(2) That the amount of labor and expense required from an architect now, even when the best of experts are engaged, and independent of their fee, is greater than was contemplated when the present schedule was adopted, but is necessary for the moulding of these parts into complete harmony with the architect's design, in all classes of work.

"(3) That the usual charge for efficient expert service is five per cent. of the cost of the special work involved where this amounts to $10,000, or more, with a gradual increasing of the percentage as the amount diminishes from $10,000, down to $2,000.

"(4) That the expense of expert service should be paid by the client as a necessary part of the cost of the work.

"(5) That the architect should select the engineer or expert, whose work should be subordinate to that of the architect, and should be done under his direction, in hearty co-operation with him.

"(6) That the architect should assume all expense for expert services necessary for the proper execution of a work, and that the schedule fee for heating and ventilation, sanitary, electrical and mechanical work should be ten per cent. on the cost of these parts.

"We therefore recommend that the schedule of charges of the Institute be so amended that the minimum charge for professional services in connection with electrical, mechanical and sanitary engineering, heating and ventilating, shall be ten per cent. on the cost of these portions of the work, the architect to select or approve any experts required and to assume all expense for their services, whether rendered by members of his personal staff or engaged for a specific work."

The above report and recommendation were read by the chairman of the committee of the American Institute of Architects before the convention in December 1900, at which time, a resolution was passed referring the whole matter to the directors, with power to amend the schedule at their discretion.

Your committee took up the matter with Mr. Glenn Brown, secretary of the Institute of Architects, in January, 1901, and Mr. Brown advised us that at the first meeting of the board of directors, there were so many matters for their consideration that they did not reach the subject and that he would advise us later as to the result. Mr. Brown did not advise us later, and in fact, we have heard nothing directly from him since.

However, the chairman of the committee of architects, Mr. Amos J. Boyden, in answer to a letter sent him by our committee, wrote us under date of January 13th; "finding in September, 1901, that the matter had not been settled, I again brought the matter before the local chapter of the Institute of Architects, in Philadelphia, and the Philadelphia chapter reaffirmed the former recommendation, which was practically the last clause of the report submitted to the general meeting in December, 1900. This later recommendation went before the board of directors prior to the recent convention held at Buffalo. At the Buffalo convention they reported an amendment to the schedule, not in the words of the report recommended by their committee, but as follows:

"'Expert Services—Where heating, ventilating, mechanical, electrical or sanitary problems in a building are of such a complicated nature as to require the assistance of an engineer, the owner is to pay for such assistance as the architect may require. Chemical and mechanical tests, when required, are to be paid for by the owner.'"

This clause appears in the schedule of "minimum charges," published by the Institute of Architects, as amended at the Buffalo convention, November 4, 1901.

The chairman of the architects' committee writes us that this amendment of the schedule was the best that could be obtained at that time: he also writes,

"It is in my opinion a great advance to get so much of a change in the schedule, and it may be possible later on to get

more nearly what we specifically recommend, but there must be some missionary and educational work done first."

All of which is respectfully submitted

S. A. Jellett,
Chairman of Special Committee.

January 21, 1902.

The following is the schedule of charges referred to in the above report:

AMERICAN INSTITUTE OF ARCHITECTS.

SCHEDULE OF MINIMUM CHARGES AND PROFESSIONAL PRACTICE OF ARCHITECTS, AS USUAL AND PROPER.

For full professional services (including supervision) five per cent. upon the cost of the work.

For partial service, or in case of the abandonment or suspension of the work, the charge for partial service is as follows:

Preliminary studies, consisting of drawings such as ground plan, one upper floor plan and elevation or perspective view of exterior, special fee according to the magnitude of the work. For full set of preliminary drawings, including the above, and such additional elevations, plans and sections as are necessary to illustrate the general scheme without working drawings, and including one revision to correct the same, one (1) per cent.; preliminary studies, general working drawings and specifications, two and a half (2½) per cent.; preliminary studies, general working drawings, specifications and details, three and a half (3½) per cent.

For works that cost less than $10,000, or for monumental and decorative work, and designs for furniture, a special rate in excess of the above.

For alterations and additions, an additional charge to be made and also an additional charge to be made for surveys and measurements incident thereto.

An additional charge to be made for alterations and additions, in contracts and plans, which will be valued in proportion to the additional time and services employed.

Necessary travelling expenses to be paid by the client.

Time spent by the architect in visiting for professional con-

sultation, and in the accompanying travel, whether by day or night, will be charged for, whether or not any commission, either for office work or supervising work, is given.

The architect's payments are successively due as his work is completed, in the order of the above classifications.

Until an actual estimate is received, the charges are based on the proposed cost of the works, and the payments are received as instalments of the entire fee, which is based upon the actual cost.

The architect bases his professional charge upon the entire cost to the owner of the building, when completed, including all the fixtures necessary to render it fit for occupation, and is entitled to extra compensation for furniture or other articles designed or purchased by the architect.

If any material or work used in the construction of the building be already upon the ground, or come into the possession of the owner without expense to him, the value of said material or work is to be added to the sum actually expended upon the building before the architect's commission is computed.

SUPERVISION OF WORKS.

The supervision or superintendence of an architect (as distinguished from the continuous personal superintendence which may be secured by the employment of a clerk of the works) means such inspection by the architect, or his deputy, of a building or other work in process of erection, completion or alteration as he finds necessary to ascertain whether it is being executed in conformity with his designs and specifications or directions, and to enable him to decide when the successive instalments or payments provided for in the contract or agreement are due or payable. He is to determine in constructive emergencies, to order necessary changes, and to define the true intent and meaning of the drawings and specifications, and he has authority to stop the progress of the work and order its removal when not in accordance with them.

CLERK OF THE WORKS.

On buildings where it is deemed necessary to employ a clerk of the works, the remuneration of said clerk is to be paid by the

owner or owners, in addition to any commission or fees due the architect. The selection or dismissal of the clerk of the works is to be subject to the approval of the architect.

EXTRA SERVICES.

Consultation fees for professional advice are to be paid in proportion to the importance of the questions involved, at the discretion of the architect.

None of the charges above enumerated cover professional or legal services connected with negotiations for site, disputed party walls, right of light, measurement of work, or services incidental to arrangements consequent upon the failure of contractors during the performance of the work. When such services become necessary, they shall be charged for according to the time and trouble involved.

DRAWINGS AND SPECIFICATIONS.

Drawings and specifications, as instruments of service, are the property of the architect.

EXPERT SERVICES.

Where heating, ventilating, mechanical, electrical, and sanitary problems in a building are of such a complicated nature as to require the assistance of an engineer, the owner is to pay for such assistance as the architect may require.

Chemical and mechanical tests, when required, are to be paid for by the owner.

SOLICITING PATRONAGE.

The attempt to secure work by offering professional services at a less rate of compensation than another architect is unprofessional conduct.

As amended at the Pittsburgh Convention, November 15, 1899.

As amended at the Buffalo Convention, November 4, 1901.

GLENN BROWN, Secretary A. I. A.
The Octagon, Washington, D. C.

(Mr. Jellett's supplementary remarks): The new printed schedule of the Institute of Architects contains the amend-

ment to the old schedule of charges, and it is the first time that they have recognized the subject. I agree with them that it is a decided step forward, in that they recognize that it is necessary to employ experts, that it is necessary that they shall be paid, and to find out who shall pay them. I believe that it is a matter which if followed up, after this entering wedge has been successfully used, will develop into a definite and tangible agreement.

The President: Is there any discussion on this report or any action that the members desire to take?

The Secretary: In the absence of any discussion, I will move that the report be received and the committee be continued. (Seconded by Mr. Kenrick.)

Mr. Jellett: The committee has accomplished partially what they started out to do. We have got the Institute of Architects to recognize this society and to recognize the position we have attained. They have not done what the committees agreed on as to the proper rule for procedure, but as I said in the report, they have accomplished a great deal. My own notion is that if it passes into another committee, working in other directions, a great deal more can be done.

The opposition came from some of the largest architects in the country, New York City, Boston and Chicago, particularly, whose business was of such magnitude as to warrant their having engineers continuously in their employ. They claimed that it interfered with their business to a certain extent; that it put other architects, not having business of the same magnitude, in the same position, and forced them to ask for additional fee for additional service.

You notice the wording of that resolution, "whether employed by architects or for specific work." These architects succeeded in defeating the adoption of the complete resolution. That is the basis, that they had men in their employ; but they made it a point that, the client having such men, their services were worth more money.

I believe that a new committee, whose membership was located in different cities, could go on and be able to take up this matter better than the present committee.

Mr. McKiever: I think it would be well to lay it over until a larger number is present. I would move that the matter be

laid over and that it be taken up for consideration, say, Wednesday afternoon or Thursday morning—if it meets with the consent of the members present. (Seconded.)

The President: All those in favor will please say "aye;" contrary-minded, "no." (Carried.)

The next order of business is the appointment of three tellers to count the ballots cast for the officers for the ensuing year. I appoint on this committee: Mr. S. A. Jellett, Mr. A. G. Paul and Mr. H. J. Barron. Now, it is after 3 o'clock and an hour must be fixed when the polls will be closed. We will fix 4 o'clock and the tellers can count after 4.

Has any member any new business to bring before the Society?

Mr. McKiever: I would suggest changing the forms of blanks for candidates for membership. I bring that before the meeting as a suggestion, and if the members see fit to take any action on it, I think we will have some good results to show a year from now at our next annual convention. I think it would be advisable to appoint a committee and to suggest a modified form of proposal blank, which a member might present to a gentleman who he knew did not have the necessary technical education, and to whom the questions in the form we now have would be embarrassing to answer. I think it would be well to appoint a committee of three before we adjourn, to suggest such a modified form. I will make that a motion, in order to bring it before the meeting. (Seconded.)

Mr. Kenrick: Would it be possible for a committee to be formed to present one standard form? I would move as an amendment that a committee be appointed to take into consideration the matter of changing our present form of application, thus having one standard instead of two. (Seconded.) The motion as amended was carried.

A discussion then took place on the subject of the financial condition of the society, after which it was moved by Mr. Switzer that the matter of the financial matters of the society be brought up to-morrow afternoon after the reading of the papers and before the topics for discussion. (Seconded and carried.)

The President: The discussion is postponed until to-morrow afternoon.

Mr. McKiever: I want to present the suggestion of the starting of some sort of correspondence by the secretary, or some officers of the society, so that the members would hear from the society and keep it before them oftener than the annual convention. What I had in view was the sending of problems to the secretary, problems which confront members in their experience, sending out a sort of monthly letter inviting a discussion and views from the members on the questions that have been submitted; then the answers to be sent around the following month. In that way he would keep the society before the members all the time and when the annual convention came around, we would, no doubt, have a larger attendance; the value of the society would be more noticed by the members, and others would be more anxious to get in in order to obtain the extremely valuable information. They would be more ready to part with their money for their dues, etc. It was only an idea.

The President: Does any one want to discuss this idea advanced by Mr. McKiever? I think it would keep our secretary busy.

Mr. Harvey: It strikes me forcibly that the secretary is a very busy man. I don't very well see how he could devote all the time that would be necessary to devote to what the gentleman suggests, especially on the salary he is now paid. [Laughter.] It is worth considering a good deal before you put that load on the secretary.

Mr. Jellett: Looking back on the reports of two or three years ago, I made a recommendation at that time: I hoped that the society would be able to furnish a bulletin monthly on that account; that it be sent to a committee on organization who would be in position to pass on questions and give them a proper answer. This takes money and I think we will first have to find the way to get the money; we really ought to have it. I agree with Mr. McKiever; it is the right thing to do; but we cannot ask any member of this society to take care of that responsibility. The matter of postage and mailing letters costs as much as printing.

Mr. McKiever: Mr. Jellett was getting at just what I wanted—a monthly publication, broadening the scope of the society, so that new members will be anxious to come in.

The President: Any further business?

A Member: I move we adjourn. (Seconded and carried.)

President: We stand adjourned until this evening at 8 o'clock. (Adjourned at 3.40 P.M.)

EVENING SESSION, TUESDAY, JAN. 21, 1902.

The meeting was called to order by the president at 8.30 P.M.

The President: Before proceeding with the regular order of business, I will announce that I have appointed the following committee to consider the revision of the blanks for application for membership: Mr. McKiever; Mr. Barron; Mr. Kenrick.

The first order of business this evening is the report of the tellers. Mr. Jellett is chairman of the committee.

The report of tellers was read by Mr. Jellett as follows:

New York Jan. 21, 1902.

American Society of Heating and Ventilating Engineers:

We respectfully report that the following vote was cast for officers of the society for the coming year:

For President:	*A. E. Kenrick	58	votes
	R. P. Bolton	20	"
For 1st Vice-President:	*Andrew Harvey	54	"
	Chas. M. Wilkes	24	"
For 2d Vice-President:	*R. C. Clarkson	43	"
	A. A. Cary	35	"
For Secretary:	*Wm. M. Mackay	71	"
	H. A. Joslin	7	"
For Treasurer:	*J. A. Goodrich	59	"
	B. F. Stangland	17	"
For Board of Governors:	*J. H. Kinealy	71	"
	*R. C. Carpenter	73	"
	*John Gormley	61	"
	*Wm Kent	49	"
	Jas. Mackay	37	"
	*C. B. J. Snyder	45	"
	J. J. Blackmore	25	"
	Jas. H. Davis	17	"
	Saml. G. Neiler	7	"
	John A. Payne	8	"

S. A. JELLETT.
ANDREW G. PAUL. } Tellers.
H. J. BARRON.

* Shows those elected.

The President: There is no action to be taken with this report, so it will simply be received and filed. These members are elected and will be installed later.

The next order of business is the reading of a paper: "Hospitals for Contagious Diseases and Their Ventilation," by Mr. Thomas Barwick.

The paper was read by author and was discussed by Messrs. Gormly, Carpenter, Barron, Jellett, Kenrick, Franklin and Paul.

The President: The next order of business is the discussion of certain topics that have been submitted: No. 1. "The Tudor system of steam heating as compared with the French system," as presented by M. Debesson in a paper read at the last annual meeting. I do not know who presented this topic. Mr. Paul, I think you ought to start the discussion.

The topic was discussed by Messrs. Paul, Smith and Gormley.

The President: The next topic is: "What is the relative economy of a hot-water heating system using the exhaust steam to heat the water compared with using the exhaust steam direct in the radiators by aid of some air-extracting apparatus?"

I think it would be well if you could get these two different points of view—if you could get some members to discuss the steam and some the hot water.

The topic was discussed by Secretary Mackay and Messrs. Kenrick, Paul, Bishop, Carpenter, Rutzler and Barron. The session was adjourned at 10:10 P.M.

THIRD SESSION, WEDNESDAY AFTERNOON, JAN. 22, 1902.

The meeting was called to order at 3 P.M.

The President: The first business this afternoon is the reading of a preliminary report on a code for testing direct radiation heating plants, presented by the Committee on Standards, together with a former discussion of the same. This code was presented a year ago and it was ordered printed with the discussion and distributed to the members, but it was not printed until late in the year. Then the members were asked to send their criticisms or suggestions to the committee and the committee was to hand in at this meeting the amended report. The committee got no suggestions or criticisms, so

that the report is just as it was a year ago. I am going to ask Mr. Blackmore to present it.

Mr. Blackmore: As your chairman has just mentioned, this report is, in a measure, a tentative one, giving a good many data with a view that members would interest themselves enough to investigate the experiments. It will not take more than a few minutes, so I will read it.

The report was then read by Mr. Blackmore and a long discussion followed, in which several points in the report were criticised.

Mr. Wolf: Mr. President: I would move that the committee be continued and thanked for their efforts; that so far as they have gone the work be published and distributed among the members requesting their views; that they revise the code, if revision is necessary, and that they report back to the society at the next annual meeting for the purpose of having it endorse the report as revised. (Seconded.)

The President: I would like Mr. Wolf to amend this motion, so that the committee can report at the next meeting; the committee may amend the code, may change it in certain instances after getting suggestions from members, and it should come before the society and say why amended, give the reasons. Then, the society in its meeting may receive it and adopt it.

Mr. Wolf: I will accept the amendment.

Chairman: You all understand the motion as read. Are there any further remarks?

The President: I would like to ask one question: Does this go to the committee named in the report?

Chairman: As I understand the motion, it does.

The motion as amended was adopted.

The President: I have asked Mr. Kent to read the paper on "The Temporary Warming of the Large Hall of the Royal and Imperial Library, Vienna, Austria, for the visit of his Imperial Highness, the Crown Prince of Germany, April 14, 1901, by Professor Edward Meter of the Imperial Technical High School, Vienna. Translated from the German by Charles F. Hauss (member of the society)."

The paper was read.

The President: You have heard the paper. Is there any discussion?

Mr. Wolf: I move you that the author be thanked for the presentation of this paper. (Seconded).

The President: I think that motion is out of order under our rules and by-laws. We are not allowed to thank a member for a paper.

Mr. Kent: We should not allow this paper to pass without some expressions in regard to it. It is an admirable paper, showing a new problem and describing it briefly and accurately, so that any one can follow it and reproduce this kind of heating if ever desirable. It shows how carefully German engineers go to work on such a problem, showing an enterprise and love of work that would be a credit to any Yankee engineer. I am very glad to get it.

Mr. Barron: I think we should take this as a model for the papers presented every year. It is thoroughly practical and scientific. It bears accuracy on the face. One who is reading it believes what he is reading about, from one who knows what he is doing.

The President: The next paper is entitled: "Depreciation, Maintenance and Interest Charges," by Reginald Pelham Bolton. Mr. Bolton is not here to-day, and I have asked Mr. Cary to read that paper.

The paper was read by Mr. Cary and discussed by Messrs. Kent, Gormly, Kenrick, Blackmore and Wolfe.

The President: We were discussing the financial condition yesterday and there was a committee appointed.

A long discussion on methods for improving the financial condition of the society then followed. On motion of Mr. Barron the subject was referred to the treasurer with the request that he submit his views on it in his next annual report.

The President: Gentlemen, we have a great deal of business before us. The next matter of business is the report of the Committee on New Form of Proposal Blanks.

Mr. McKiever read the report on proposal blank.

New York, January 22, 1903.

American Society Heating and Ventilating Engineers.

Gentlemen: Your committee, which was appointed for the purpose of submitting a revised form of proposal blank instead of the present form, beg to report as follows:

The present proposal blank has been used as a model for the revised one; the following changes have been made as the unanimous suggestion of the committee appointed.

The first page to remain unchanged.

The second page to have the following title at the head: "Professional Experience of," and underneath, "General Experience of," and the balance of the page to be lined off so that the candidate can fill in all the information which he desires to give.

The third page, the change suggested is the omission of the sentence, "Giving the years and noting particulars (if any) as to his sole and responsible charge of work."

The only other change which the committee suggests on the third page is at the bottom of the page, omitting the sentence, "Certifies that the above statements are correct;" adding after the words, "Membership Badge," the sentence, "The society agreeing to reimburse him for same."

This constitutes all the changes which your committee think necessary to make in the form of proposal blank and suggests the adoption of same as recommended.

In relation to Article 3, Section 2, of the Constitution, your committee thinks that the word, "Contractor" should be inserted in the following sentence: "An applicant for membership shall be a heating or ventilating engineer or expert."

Respectfully submitted,

Alfred E. Kenrick,
Wm. H. McKiever,
Hugh N. Barron.

Mr. Wolfe: I would move, Mr. President, that on account of Professor Carpenter's views on the matter there should be a broader field opened and that manufacturers conversant with heating and ventilation should be eligible.

The President: The report ought to be printed and submitted to the members before we vote on it. The changes consist in wiping out everything in regard to a man's preparation.

Mr. Bishop: I should very much hate to see the society so reduced in character that it would have no weight with the outside world. If membership is all we are looking for we can

change the name and membership and requirements and get members. I belong to several different societies; I am sure that I voice their sentiments when I say it is a detriment to allow a member to come in simply as a manufacturer with no other requirement for membership. At the last two meetings of two societies to which I belong the matter was threshed out and they decided to disband and start over again. I think we are making a mistake in which others have had experience. I think we are reducing the requirements too much. I think it ought to be a vote of the whole society.

Mr. Wolfe: I embodied in my motion the manufacturers who are conversant with heating and ventilating.

The President: Under the constitution and by-laws this report cannot be adopted now, all of it at least; there is a suggestion here as to an amendment of the constitution; that amendment cannot be made except in compliance with Article X.

Mr. McKiever: The object of the change of form of proposal blank was to reach those who would be welcome members to us, men who have been actively engaged in the heating and ventilating business for 20 or 25 years, who could not answer some of the questions or who would be sensitive as to their age or as regards the technical questions; that was the aim. Those are the people we want to reach, not those who would be more commonly termed "rank outsiders."

Mr. Kenrick: During the discussion in the committee, they were well aware that they had no authority or the association had no authority to adopt those recommendations, but they expected to get along to that point and the subject-matter would be referred to the Board of Governors as called for in the by-laws.

Mr. Barron: It does not mean to change the by-laws. The members of the committee found in their experience that there were certain gentlemen who they knew ought to be here, and would be here, only they objected to filling out certain things in that blank. We simply presented a blank with suggestion to the Board of Governors to get a different blank, so that a member would not be subjected to embarrassment when he asks a person to join this society. We do not propose to change the constitution and by-laws, and I do not think we want to.

Mr. Kenrick: I think if it is intended to add the word contractor, it would be necessary to change one article in the constitution and by-laws.

Mr. Barron: We should move to strike that out.

Mr. Wolfe: I still think it would be well to include the clause for manufacturers who are identified or conversant with heating and ventilating.

Professor Carpenter: I should like to see that added recommendation. It would strengthen us in every way. If the membership is limited, I think there would be no danger as to our standard going down. I can hardly see the necessity of putting in the word contractor. He is an engineer nine times out of ten and consequently he would come into our society. A manufacturer sometimes does not think he is an engineer, although really in accordance with our recent notions, nearly all manufacturers are engineers. It is on that account that I propose to put them in. I found out on first solicitation of a few men that we will never get them if we have our bar out, because of some action taken in the early meeting of the society. That is one particular reason for putting in this phraseology which Mr. Wolfe reports.

Mr. Barron: The membership committee also understands that there is no danger from unacceptable people getting in, for every applicant goes before the Board of Governors—simply changing the application blank and making the work easier. That, to my mind, is quite simple. It does not require that the constitution and by-laws or character of the society shall be changed. There is a good deal of snobbery in this country under that head. The mechanical engineers of Great Britain are not so rigid in the requirements of their applicants. The society is exceedingly prosperous and that is an example to us, that we should not be so rigid in our blank.

Mr. Smith: I think that our blank is rather a source of embarrassment. I spoke to one man; he came in and is now a member, but he could not fill out the requirements; he was not good enough, he said. But a man who learned from him the business could answer the questions while he could not. I do not think it is necessary, in order to get manufacturers in, to change the constitution. I have put in several as associate members. They can all get in as associate members.

The President: Suppose some one makes a motion to refer this report to the Board of Managers with instructions to carry out the recommendations of the report as quickly as can be made.

Mr. Smith: I make that motion. (Seconded and carried.)

The President: The report is referred to the Board of Managers.

Mr. Smith: I have put into the hands of the treasurer the $100 from the friend who wanted to contribute to this society. I would, therefore, move that a vote of thanks be made to this gentleman.

(A unanimous rising vote of thanks was given to the donor.)

The President: Gentlemen, the motion is carried unanimously. Mr. McKiever is Chairman of the Committee on Uniform Contracts and Specifications.

The report was read by Mr. McKiever as below:

(On motion, duly seconded, it was voted that this report be printed and sent to the members and discussed at the next annual meeting.)*

New York, January 22, 1902.

American Society of Heating and Ventilating Engineers.

Gentlemen: The Committee on Uniform Contract and Specification which was appointed by our president after the last annual meeting, for the purpose of recommending a Uniform Contract and Specification, beg to report as follows:

Your committee has done all its work in relation to discussing the subject for which it has been appointed, by corresponding with the members of the committee and with two meetings held in New York City.

The committee begs to extend to Professor Kinealy its thanks for his very valuable suggestion relative to the matters considered.

After careful consideration, the committee decided that it would not be possible to take up the question of Uniform Specification, devoting its labors to the preparation of a Uniform Contract, the draft of which is submitted for the consideration of the members at this convention.

* A final report was brought in at the next annual meeting in January, 1903, and it will be printed in the next volume.

The committee sincerely hopes that the members will give the contract, as suggested, careful consideration, and that the succeeding committee who may be appointed will take up and complete the work of this committee, the necessity for a uniform form of contract being very much recognized throughout the country.

The committee suggests that in the appointment of successors to the present committee, that the president give consideration to the suggestion that the committee appointed should be from one locality, in order that no time need be lost in corresponding, meaning that more meetings could be held and the matters gone over.

We also think that it would be a good idea if a circular letter were sent out informing all members of the society of the names and addresses of the new committee appointed, and requesting that they would send suggestions to the committee, as to points to be covered in the Uniform Contracts and Specifications. This will greatly help the committee in their labors, and we feel that by the time of our next annual convention, or possibly at our summer convention, the committee may be able to make a report which could be finally adopted at the annual convention in 1903.

It is further suggested that the president, in the selection of a Committee on Uniform Contract, that the committee should have at least one consulting engineer and one contractor constituting the committee.

Respectfully submitted,

WM. H. MCKIEVER, Chairman.
H. J. BARRON.
A. E. KENRICK.
R. P. BOLTON.
JOHN D. HIBBARD.

DRAFT FOR A FORM OF CONTRACT FOR HEATING AND VENTILATING ENGINEERS.

January 15, 1902.

Omit if one person.

This Agreement made this day of 190. . by and between (the party or parties forming the copartnership of or trading under the title of)

Omit if one person or a firm.

(A Corporation duly organized and existing under the laws of the State of
and having a residence or principal office in the State of)

Business address.

of

Omit if one person.

Party of the first part, hereinafter designated "the purchaser" and (the party or parties forming the copartnership or trading under the title of)

Omit if one person or a firm.

(A corporation duly organized and existing under the laws of the State of , and having a residence or principal office in the State of).

Business address.

of

Party of the second part, hereinafter designated "the contractor."

WITNESSETH.

That the parties to these presents, each in consideration of the fulfilment of the agreements herein contained, for themselves, their successors and assigns, do agree as follows:

I. The contractor shall provide all the material and perform all that work composing

Title of specification.

to be erected upon, placed in, or attached to building
the owner of which is
according to the specification and cloth print plans of said work in said building, hereto annexed numbered, as to specifications pp.
to and as to plans. Sheets
to and identified by the initials of the parties hereto.

Sun prints should be used.

Said specification and plans being coöperative and intended together to describe and illus-

trate the said work and materials, having been prepared therefor by
(Architect) of the purchaser,
(Engineer) of the purchaser.

II. The purchaser shall cause to be delivered to the contractor, two copies of said drawings and specifications and of all further detail drawings.

III. The said (architects) (engineers) are hereby designated by the purchaser as their agents and representatives for the purposes of illustrating, developing, explaining and directing and certifying for payment upon the said work and materials, and the purchaser shall cause such further drawings, explanations or directions to be furnished to the contractor by said
as may be necessary to detail and illustrate the work and materials comprised in said specification and plans.

Strike out either Engineer or Architect.

IV. Such further details, explanations and directions shall be carried out under the conditions of this contract, and the contractor shall conform to the same as far as they shall be consistent with the original specifications and plans hereto annexed.

V. The contractor shall retain as his property one copy of all specifications and plans furnished to him. All other copies shall, upon the completion of the work and upon final payment being made, be returned to the said

Purchaser or Agent.

VI. The said specifications and plans are intended to describe and illustrate a working apparatus, and such necessary details, workmanship, methods and material, as are commonly required to complete same and effect operation.

In case of a discrepancy between said specifications and plans, the contractor shall follow that which will most effectively contribute to

the operation of the apparatus and in case of disagreement the matter shall be decided as provided in Article XX.

VII. No alterations, additions and deductions shall be made by the contractor except upon the written direction of the agent of the purchaser, or upon the written order of the purchaser.

The contractor shall upon such direction or upon request of the purchaser in advance of such order, provide a written detailed estimate of the cost of such alterations, additions or deductions. If upon the delivery of such estimate, an order or direction to proceed with said alterations, additions or deductions be not made within a reasonable period, then the contractor shall be entitled to and shall receive an extra sum of time corresponding to the delay thereby caused to the completion of the work, based upon such part of the work as is affected by the same. In case of a disagreement as to the cost value or extent of such alterations, additions or deductions, the question shall be decided—as provided in Article XX.

All such additions, alterations and deductions shall be carried out by the contractor in the same manner and with like materials and workmanship as if they formed part of this contract.

VIII. The contractor shall remove defective material, or material which has been rendered defective by faulty workmanship, upon written notice by the agent of the purchaser and shall be allowed a reasonable time in which to effect such removal and the substitution of suitable and proper material in its place.

In case of disagreement as to the character of said material, or as to necessary time for removal and replacement, or as to time lost in deciding the question, the said questions shall be decided as provided in Article XX.

IX. If the contractor shall fail for any cause to properly prosecute the work, such failure being notified at the time in writing by the agent of the purchaser to the contractor and his bondsman, then the purchaser may give him, in writing, three working days' notice of such failure and of his intentions to apply to the referee for authority to undertake and provide the necessary work and materials for a due prosecution of the work and performance of the contract.

In case of a failure or assignment on the part of the contractor, the owner shall be at liberty, within three working days after such failure or assignment, to require the referees to assess the value of the work at that date completed, and to retain the balance out of the moneys due to said contractor, and to hold any surplus over said balance until the entire completion of the conditions of this contract is certified by said referees.

Should the purchaser, his agents, contractors or sub-contractors, obstruct or delay the work of this agreement by neglect or default, or by unavoidable delays in construction, delivery or erection of the materials or work, or by the action of nature, fire, frost or storm, or by the abandonment of other work by his or their employees, or by the failure of, or assignment by the purchaser, then the contractor shall be allowed an equivalent in time for completion, to the time lost by reason of any one or all of the causes aforesaid, and the extent of such allowance shall be decided as provided in Article XX.

Liens, &c. In the case of failure of or assignment by the purchaser, or foreclosure by mortgages on the property on which said contract, work and materials are being erected, the purchaser shall notify his creditors, mortgagees or assigns of the conditions of this contract.

X. It is hereby agreed that the ownership of the material and work herein included is not vested in the said purchaser until said material and work are completed and payments in full shall have been made.

The purchaser expressly agrees and stipulates that he shall not at any time mortgage or pledge any part of the material or work composed under this contract until its entire completion.

The purchaser further agrees that all moneys received by him, for or on account of payment by him of the value of work and material of this agreement, shall be kept by him in trust for the purpose of this agreement.

The purchaser shall, nevertheless, be at liberty to retain out of any payment then due on material, the value of any lien upon the material and work of the contractor duly evidenced in writing to the said contractor, stating his knowledge of same and his intention to retain moneys due and materials belonging to the contractor.

XI. The purchaser agrees to finish such work and materials as are not included herein, but are necessary to the effective erection, completion and fulfilment of the work of this agreement,

Time. and to so advance such work and materials as not to delay the completion of the work of this agreement, and in consideration of same, the contractor agrees to complete the whole of the work on or before the

Insert date. 190

it being agreed that the following work shall be prepared by the purchaser in the order and times as follows:

Progress of building..
Completion of shafts..
Erection of foundation..
Closing in of windows..

It is understood and agreed by the parties hereto, that time is of the essence of this agreement. The contractor agrees to advance his work and materials in such order and manner as in no way to delay the construction of other work not herein included, and for such purpose only will provide necessary overtime or night labor.

XII. The contractor agrees to assume all risk of loss, damage or injury upon his work, materials or employees until presentation of final certificate, and agrees to hold the purchaser harmless in respect of same.

The contractor will insure his own work, material and tools against damage or loss by fire, and will also keep himself insured against liability on account of accidents to or by his employees.

The purchaser is at liberty to insure the same liabilities for his own interest or protection in same.

XIII. The purchaser is at liberty to make necessary temporary use of portions of the apparatus herein included, but the contractor shall not be liable for wear and tear, damage or accident, caused by such temporary use of said apparatus, unless apparatus is operated by contractor for such temporary use.

XIV. The contractor hereby guarantees the apparatus, material and workmanship furnished by him under this agreement for the period of   to be free in operation from defects due to inherent faults of material or defect in workmanship. It is agreed that the indemnification of the purchaser by the actual manufacturer of the material, apparatus and their respective workmanship shall release the contractor from obligation as to faulty material and workmanship.

Time of Guarantee.

XV. The contractor agrees to provide and pay for license, royalty or permit in respect of the use of any patented device, apparatus or method specified in the specification hereto annexed, it being agreed, however, that the indemnification by the patentee of the purchaser shall release the contractor from liability in respect of the use of said patented device, apparatus or method.

XVI. The contractor agrees that articles particularly described and specified in the specification or plans shall be provided and that substitutes shall not be installed without previous written acceptance by the agent of the purchaser.

XVII. It is agreed that the tests or trials of apparatus, if any, specified in the specification hereto annexed, shall not be unduly delayed by either party hereto, also that in the case of a test dependent upon natural conditions not attainable at the time of completion, an equivalent test shall be made if reasonably practicable, or the date shall be fixed for such test to be made. In respect of such test an amount not exceeding per cent. of the contract price shall be retainable by the purchaser as a guarantee of satisfactory compliance unto the conditions set forth; and said amount shall, be held by the purchaser in trust for the contractor until a certificate by the agent of the purchaser, or in his default, by the referee, of satisfactory compliance with said conditions is presented to the said purchaser. Such certificate must be issued sixty days after final completion.

XVIII. The consideration herein is based upon and requires of the contractor the use of union labor and union made goods where same are demanded by the recognized labor unions of the locality in which the work is being installed.

It is therefore agreed by the parties hereto that they shall in their respective parts, obtain

from the authorized representatives of the aforesaid recognized labor union or unions, an agreement on their part that in consideration of the employment in and upon the work, of members only of their said unions at their current rates of wages and under the conditions of labor then existent, they shall not order any special or sympathetic strike upon the work by the members of their union, save only and except a general strike of a trade or trades of which they are members, or a lockout by the purchaser, if ordered by an organization of which the purchaser is a member, both of which exceptions shall be held to release the parties hereto from liability to the other in respect of this condition of this agreement.

XIX.

Total Price.

It is agreed that the sum to be paid by the purchaser to the contractor in current funds of the United States of America, shall be $ subject to addition or deduction in manner hereinbefore provided, and to be paid by the purchaser to the contractor in the following manner:

Period.

All such payments shall be made upon the certificate of the agent of the purchaser which shall be rendered within working days after the presentation of a requisition to the agent by the contractor, or in default thereof upon a certificate of the referee in the manner provided in Article XX.

Retain percentage.

The final payment of per cent. shall become due and payable upon the certificate of the agent of the owner, or in his default of the referee, that the work is complete. It is agreed that no payment shall be construed as an acceptance of work or materials afterwards discovered to be defective or incorrect, and that only the final payment shall be conclusive evidence of entire completion of the work. It is agreed that

Date of requisitions.

requisitions are to be rendered by the contractor upon the day of month, and shall be certified to by the agent of the purchaser within working days hereafter or in his default shall be handed to the referee, which decision shall be rendered within ten working days after receipt thereof. It is agreed that upon receipt of certificate, the purchaser will pay same within days of receipt of same, and thereafter, if delayed, interest at the rate of 6 per cent. per annum shall be added to the amount certified.

XX.

Referee.

The parties hereto mutually agree that all questions in dispute between them in connection with this agreement, the specification, and the plans, shall be referred promptly, at the request of either party in writing to the other, to herein designated by both parties hereto as the referee, the cost of whose services is to be borne jointly by the parties hereto and shall be promptly paid by each in the proportion stated.

In case of disagreement by either party with the decision of said referee, his decision may be submitted in writing by said party with all necessary evidence, to a board of three arbitrators, of which said referee shall be one, and one shall be appointed by each party hereto, the cost of whose services shall be charged upon the party making the submission or

The parties hereto designate and appoint as the said arbitrators:

Two Arbitrators.

For the purchaser

For the contractor

In the event of the death of, or refusal of, either of the three, his successor may be named and substituted in writing by the party designating and appointing him. The decision of

said board upon any question submitted to them in connection with this contract is agreed to be final and binding upon both parties hereto, their successors or assigns.

XXI. The parties hereto mutually agree for the mutual protection of each other to execute a bond to each other with a responsible Surety Company in the sum of $

conditioned for the true and faithful performance of the conditions they have respectively entered into under this agreement. A copy of this agreement and of the specification and plans is agreed to be filed and attached to said bonds. It is agreed that all modifications and changes in the agreement and a list of payments as when made and received, shall be filed by both parties with the Bonding Company.

IN WITNESS WHEREOF, the parties hereto have set their hands and seals and the corporate seal of the corporation hereinbefore named by the hand of its

the day and year first above written.

The party of the First Part
In presence of

Party of the First Part.

The party of the Second Part
In presence of

Party of the Second Part

Countersigned by

Surety Company
With authority of Surety Company annexed.

The President: The next business is the discussion of the report of the Committee on Tests. I would suggest that we discuss that report this afternoon. The report is very short. Mr. Cary, will you read your report and open the discussion? You are chairman.

Mr. Cary then read the report of the Committee on Tests.

REPORT OF THE COMMITTEE ON TESTS.

January 21, 1902.

Gentlemen: Your Committee on Tests regrets the necessity of reporting again at this time that, owing to lack of funds, and possibly through lack of sufficient advertising of its existence and purpose (through the channels of this society and elsewhere) it has not been in position to conduct tests of apparatus, or systems for heating and ventilating during the past year.

Last spring, at the time the District Attorney of the County of New York was investigating the nuisance existing in the New York Central & Hudson River Railroad tunnel in this city, the services of this committee were offered to investigate any system of ventilation that might be proposed to suppress the existing nuisance, and had not the Grand Jury been so strongly inclined towards electric traction as a remedy (to the exclusion of any system of ventilation) our offer of services would doubtless have been accepted.

Your committee, in case it be continued, sincerely hopes that other similar opportunities may present themselves during the coming year, and also hopes that after the reading of this report, its existence will not be forgotten by the members of this society, who doubtless encounter many vexed questions during the course of their work which might properly be referred to the Committee on Tests.

Albert A. Cary, Chairman.
Wm. Kent.
C. M. Wilkes.
Jas. Mackay.
B. F. Stangland.

Mr. Wolfe: I believe that the committee is one of the most desirable committees that we have in our society. They have not been able to give the money, but there are members who, if they would take the trouble to submit data that they have already—I know certain members of the society who have data which would interest all of us—the committee could check back the information and they would be glad to report upon it. If there is any possible way to get money to proceed

to any test and investigation, I should like to see them get it. That is one road to public confidence. If we give people information, we can get their confidence.

The President: We have one other question to consider: that is the report of the committee to arrange with the Institute of Architects on the matter of professional charges. There was a motion yesterday to continue the old committee, but the matter was laid over until this afternoon. What will you do—appoint a new committee, or discharge the committee as at present?

Mr. Harvey: I would move that the whole committee, having that in charge and knowing more about that than anybody else, be continued until the final report is made. (Seconded and carried.)

The President: We still have two topics for discussion put down for this afternoon, but we also have a dinner to discuss at 6:30.

Mr. Cary: I move that we adjourn the topics of discussion until the meeting to-morrow. The motion was agreed to. (Adjourned at 6:03 P.M.)

FOURTH SESSION, THURSDAY MORNING, JAN. 23, 1902.

The Chairman (Mr. Kenrick) called the meeting to order at 11:13 A.M.

The Chairman: I will bring up for discussion, topic No. 4, which should have been taken up yesterday afternoon: "Can a hot water heating apparatus be improved by using a steam boiler to transmit the heat to a heater for the purpose of warming the water to heat the radiators?"

Is there anything to be said on that subject, gentlemen? [After a pause]. There being nothing to be said on that subject, we will pass to the regular order of business. Mr. Kent has been delegated to read the paper—"An Investigation into the Difference between the Coefficients for the Thermal Conductivity of Building Materials Obtained by Peclet and those Obtained by Later Experimenters," by A. B. Reck, Copenhagen, Denmark (member of the society).

The paper was read by Mr. Kent.

The Chairman: Gentlemen, the paper is before you for discussion. Any gentlemen wish to speak in reference to this

paper? [After a pause.] There being no one to discuss the paper, we will pass to topic No. 6: "What is the advantage (or disadvantage) of broad grates with shallow firing over deep fireboxes and intense concentrated fires on small grates in hot-air furnace-heating?"

The topic was discussed by Messrs. Kent, Kaiser, Carpenter, Smith, Lyman, Mackay, Wolfe, Oldacre and Gormly. Topic No. 1, The Tudor System of Heating, was then discussed by Messrs. Barron, Gormly, Trexell, Webster and Paul.

After the discussion the session adjourned at 1:15 P.M.

FIFTH SESSION, THURSDAY AFTERNOON, JAN. 23, 1902.

The meeting was called to order at 2:45 P.M.

The President: We will take up the paper read this morning, "An Investigation into the Difference between the Coefficients for the Thermal Conductivity of Building Materials obtained by Peclet and those obtained by Later Experimenters," by A. B. Reck, Copenhagen, Denmark (member of the society). Mr. Cary wishes to speak on that subject.

The paper was discussed by Messrs. Cary and Barron.

The President: We will pass to topic No. 8: "The advantage of so constructing hot air furnaces, etc., as to take the smoke, etc., from the lowest point of the heater." Anything to be said on that subject? [After a pause.] We will pass on to No. 9: "The necessity for the maintaining the proper amount of moisture in the air of artificially heated houses, under the law that heated air demands moisture in proportion to its expansion."

Anything to be said on that? [After a pause]. If not, the next in order will be the reading of a paper: "The Performance of Centrifugal Fans under Actual Working Conditions," by H. Eisert (member of the society).

Mr. Chew makes the suggestion that the reading of this paper be laid over till after four o'clock, when some of our other members will be present at that time. What is your pleasure, that the subject be laid over?

A Member: I move that as a motion. (Seconded and carried.)

Mr. Kenrick (in the chair): Will Mr. Wolfe please take the chair at this stage of the proceedings?

(Mr. Wolfe takes the chair.)

The Chairman: The next business in order is the reading of any miscellaneous papers. Are there any that have not been presented or read? There appearing to be none, we will proceed to the next topic. If there are any topics that have not been discussed, it is now in order for any member to bring them before the society.

Mr. Kenrick: At this time, the subject of the Midsummer Meeting is brought up and discussed. I move that the whole subject matter of the Midsummer Meeting be left to the incoming Board of Directors. (Carried.)

Mr. Snyder: I would like to bring one matter before the attention of the society this afternoon, speaking from the position of the architect. In discussing matters many times during the past season, the question has arisen, what is the basis of charges made by members of this society to the architect? The architects say that they have their own schedule of charges, and this society should also have a schedule which can be accepted for the client. I would like to make a motion that the subject of preparing a schedule of charges adopted by the society be offered to the Committee on Conference with the American Institute of Architects, of which Mr. Jellett is chairman. (Seconded and carried.)

Mr. Carpenter: I think I am in order in wishing to thank the New York members for the entertainment given to the society last night. I make a motion to that effect.

The Chairman: Strictly speaking, I suppose it is out of order. I believe it is customary for all bodies of this nature to take such action. I think that the clause forbidding such action refers to the authors of papers, etc. I will rule that the motion is in order. Is it seconded? (Seconded and carried.)

The Chairman: Gentlemen, inasmuch as there is a provision for discussion later, I think the installation of the new officers is now in order. You heard the announcement on Tuesday evening as to the election. I would appoint Messrs. Chew and Smith to conduct our new President, Mr. Kenrick, to the chair.

The new president was conducted to the chair.

The Chairman: Gentlemen, I have the honor to introduce to you the gentleman whom you already know, Mr. Kenrick,

our new president. I bespeak for him your usual courtesy. [Applause.]

Mr. A. E. Kenrick (president elect): Mr. Chairman, Officers and Members of the American Society of Heating and Ventilating Engineers: You have seen fit to honor me by the election to the highest office within your gift, and in the acceptance of the same I fully realize the responsibility resting upon me. To be sure, we are a young organization, but I feel that we must forge ahead and attain to the high pinnacle mentioned last evening by a gentleman at the banquet.

Your president alone cannot bring the society to that high apex which we wish to attain, without the voluntary assistance of each individual member, but I will endeavor for the ensuing year, to the best of my ability, with your coöperation and assistance, to make the society one of the foremost in our profession.

Again thanking you for the position with which you have honored me, I will take my seat. (Applause.)

The same committee then conducted to the platform such of the other officers elect as were present, and they were formally installed into their offices.

The President: We will now take up Topic No. 11: "What can we do to impress upon owners of buildings and architects the necessity of adequate smoke flues for heating apparatus?" The topic was discussed by Messrs. Wolfe, Snyder and Rutzler.

On motion of Mr. Chew, the topic was referred to the Committee on Standards, with the request that it report on the subject at the next annual meeting.

A discussion then took place on the question of holding a special meeting to celebrate the tenth anniversary of the society. It was moved that a special committee of ten be appointed to devise some plan of making the tenth anniversary of the meeting of special interest. (Seconded and carried.)

Topic No. 12 was then taken up for discussion, viz.: "What is the proper proportion of grate surface in a boiler to radiating surface in a building, in low-pressure steam and hot-water heating?" It was discussed by Messrs. Hamlin, Harvey and Barron.

The president then read a list of the committees for the ensuing year, as follows:

COMMITTEES 1902–1903

Compulsory Legislation

W. M. Mackay, *Chairman*

Henry Adams	T. J. Waters
Andrew Harvey	B. H. Carpenter

Uniform Contract and Specification

S. A. Jellett, *Chairman*

Wm. H. McKiever	R. P. Bolton
H. J. Barron	F. A. Williams

Standards

J. H. Kinealy, *Chairman*

Herman Eisert	J. J. Blackmore
H. A. Joslin	Chas. G. Folsom

Tests

A. A. Cary, *Chairman*

Wm. Kent	Jas. Mackay
C. M. Wilkes	B. F. Stangland

The President: The committee to be appointed, under vote, for making special arrangements for the Tenth Anniversary, and the Committee on Code, covering grate and fire surface, I will have to announce later, probably through the medium of the trade papers. I would like to think that matter over.

Is there anything further to be brought before the Society at this time—any business, papers or discussions? If not, a motion to adjourn is in order.

Mr. Dean: I move we adjourn. (Seconded and carried).

Adjourned at 5 P.M.

AMERICAN SOCIETY HEATING AND VENTILATING ENGINEERS, 1902.

List of members and guests present at the Eighth Annual Meeting, January 21, 22, 23, 1902.

MEMBERS

N. P. Andrus
C. E. Adams
H. Addams
H. L. Annis
C. R. Bishop
T. Barwick
H. J. Barron
F. P. Blodgett
J. A. Connolly
F. K. Chew
B. H. Carpenter
A. A. Cary
R. C. Carpenter
Mark Dean
A. C. Edgar
A. H. Fowler
H. C. Faulkner
John Gormly
H. B. Gombers
R. Hankin
C. F. Hauss
S. A. Jellett
H. A. Joslin
J. H. Kinealy
A. E. Kenrick
W. M. Mackay
W. H. McKiever
A. S. Mappett
G. O'Hanlon
A. G. Paul
J. A. Payne
E. Rutzler
W. H. Switzer
C. B. J. Snyder
H. A. Smith
B. F. Stangland
P. H. Seward
T. N. Thomson
W. Webster
W. F. Wolfe
W. S. Washburn

GUESTS

J. M. Bruce
R. R. M. Carpenter
C. H. Corbett
W. L. Clark
L. D. Collins
F. Dobson
Albert B. Franklin
C. C. Finkler
H. A. Gouge
C. A. Geoghegan
A. T. Henderson
B. N. Hurd
H. W. Jones
M. L. Kaiser
I. G. Klemm, Jr.
I. O. Koven
G. H. Koven
C. Kiewitz
C. M. Lyman
W. W. Macon
E. L. McCulloch
J. G. Marsh
C. E. Oldacre
H. H. Ritter
R. M. Stockwell
T. R. Schenck
J. C. F. Trachel
C. P. Vandeveer

PAPERS

OF THE

EIGHTH ANNUAL MEETING,

New York, January 22, 23, 24, 1903.

XCIII.

HOSPITALS FOR CONTAGIOUS DISEASES AND THEIR VENTILATION.

BY THOMAS BARWICK

(Member of the Society.)

Hospitals for contagious diseases should be built of fireproof materials. The cruciform plan should be considered as the best for such a building, or they should be built with provision for the administrative portion at the center and radiating wings for the wards and sick rooms.

The building should be arranged so that at one point, either front or rear (preferably the rear), the reception of the patient may be provided for without being brought in contact with the administration offices of the building. Arrangement should also be made so that the patient may be quickly transported to the various wards or confining rooms, either by means of an elevator or graduated stairway, without passing through any of the administration portion.

The design for such a building would be two stories in height, the sick wards being placed on the upper story and the convalescing wards or rooms on the first story. The basement portion of the administration part of the building should be arranged to receive the mechanical plant for the heating and ventilating, and other requirements, the wings being left for the heating and ventilating ducts, etc.

The first story of the administration portion should be arranged for the administration uses only, the second story for operating rooms, etc., in connection with the wards. The floors throughout the building should be of granolithic; the walls on the inside should be of glazed brick, terra-cotta, or tile, so that they may be washed down at any time. Partitions should be constructed in a similar manner, and the doors and window

sash should be made of iron, or covered with metal, and as little paint as possible should be used in the building.

The first floor should be arranged with individual rooms or double-occupant wards. In no case should the wings extend beyond six beds in depth, allowing for twelve occupants in the ward, with a preference for smaller wards than the above, so as to isolate the different diseases as far as possible. There should also be a preference for wards on the second story with ante-rooms, baths, toilets, etc., arranged adjoining the administration portion, and separated by proper closed vestibules. The building should also be provided with its own domestic machinery, such as cooking, laundry appliances, etc.

Such a building should be built with proper elevation above the surrounding country to give it a free and clear drainage from any surface water that may interfere with its foundations, or percolate through the floor of the basement.

The heating and ventilating apparatus should be confined to the basement portion in the wings. The building should be arranged to be warmed by a system of heating stacks placed on standards and enclosed in galvanized iron at the foot of the vertical flues in the basement, and arranged with double dampers, so that at any time if a higher temperature is required in one room or ward, the same can be secured through the medium of warm air, the air passing into the various rooms through large plain fretwork grills. Each room should have a thermostat with a wide range, so that the temperature may be maintained to suit the conditions.

The air supply should be brought from a point as far from the general building as possible, so as to provide for uncontaminated air, and should be forced through the rooms by means of a blower driven by any motive power that may be adapted to the work.

The air supply for such a building should be carried up in the walls through terra-cotta flues and enameled or glazed on the inside so as to be germ proof as far as possible, terminating in the rooms at a point say eight feet above the floor line, so as to provide for the distribution of air through the rooms without drafts upon the patients, and in the wards the inlets should be as near as possible between the beds.

The velocities of air entering into the rooms should be

extremely low, if possible, not over 250 feet per minute for any current of air entering the room, and should be tempered at the inlet of the fan by means of a tempering coil controlled by thermostats to a temperature of 65 degrees maintained by thermostatic regulation, and the additional heat supplied by the stacks at the foot of the flues.

The fan for doing this work should be constructed so that there will be no noise, and should be of large size so as to run at a low velocity. The arrangement of the heating apparatus, including the piping, radiators, tempering coils and the boiler, should be of ample size to maintain the building at 70 to 75 degrees under all conditions of weather, with sufficient reserve in all of the indirect stacks used as reheaters, to increase the temperature in any room from 80 to 85 degrees. The boiler capacity for domestic use should be provided as well as for the heating. This could be accomplished by means of two boilers, and as far as possible there should be a duplication of parts of the system, so that should any portion of the apparatus become out of order, it would not necessitate the closing down of the building.

In supplying air to such a building it is necessary to have a very large volume, so that the percentage of vitiated air will be kept to a very low degree. For buildings of this class I should recommend not less than 5,000 to 6,000 cubic feet of air per hour for each occupant; that is, to each individual in a room. The administration portion of the building could have slightly less than this amount, but my preference would be for the full volume throughout all portions of the building.

The vitiated air from the various rooms should be collected through vertical flues carried down to the basement connecting into sealed ducts formed of brick or terra-cotta, and the inside of each flue and duct should be enamelled or finished in similar manner to the heat flues. Each wing should be entirely independent of the other, and the vitiated air ducts connected into vertical uptake shafts (or they may be carried down to one central point to a vertical shaft), carried far enough above the top of the building so that the discharge from the shaft will not contaminate the air in the neighborhood.

The vitiated air should be collected into a receiving chamber at the foot of the vertical uptake shafts or shaft and passed

through a disinfector, in which the air should be burned, either by means of coke fire or a furnace especially designed, or by highly heated steam coils, a jet or spray of steam being introduced into the chamber so as to destroy the disease germs as far as practicable, in the same manner as clothing is disinfected by means of steam disinfecting chambers, or the air could be passed through screens in one of the well-known disinfecting tanks that are at present in use in various parts of the country. By these means we may be able to destroy the live germs passing through the air.

Sweepings and dust from these rooms should also be conveyed to this vertical uptake shaft, either by means of a blower or by an induced draft in the vertical shaft. Perforated steam pipes could be introduced in the main air supply ducts and in the vent ducts and vertical flues where possible, so that the entire space may be flooded with steam. Humidifiers should be placed in each room and automatically regulated. The windows in such a building should be sealed in such a manner that they cannot be opened to the outside air, dependence being placed upon the heating and ventilating apparatus.

Provision should also be made for the fumigation of the rooms by such means of fumigation; by Formaline or other disinfectors as are at present in use and found adaptable. Each room could be separately treated through the supply and vent flues by using proper dampers.

Water should be introduced (both hot and cold) into each of the wards and rooms, so that the walls, ceiling, and floors may be thoroughly washed down. As far as possible, the ventilation from the rooms would be best if taken near the floor, as the tendency for the heavier bodies and small particles of clothing, etc. is to settle at the floor line; therefore, they will be conveyed by the air current to the various outlets and thence to the disinfecting chambers. Clothing should be thoroughly disinfected in disinfecting chambers placed in each of the wards or wings before being taken to the laundry, these chambers being located at some point accessible to each ward independent of the administration portion of the building.

Such buildings can be built in cities where the population is crowded, or situations that are of limited area in their districts, without fear of contagion to any portion of the surrounding country.

Some of the buildings that I have investigated have been frame structures, many of them being supplied with simple direct heating apparatus, the radiators being placed in the rooms, and no proper provision being made for the supply of fresh air or ventilation. The studding of the building was constructed of wood and plastered, with the idea that the occupancy of the building would be temporary, and so that any time the building may be burned or destroyed; but the general run of these buildings have been in use from twelve to thirteen years. Through improper care and lack of funds, the buildings have become permeated with vermin and bacteria, and as the buildings are constructed with no proper provision for ventilation or supply of fresh air, they are entirely unfit for the purpose designed. Some of these buildings have small ventilators placed in the ceilings, connected with cowls on the roofs, emptying into the surrounding air without any provision to destroy the germs in the vitiated air, and allowing the same to escape to the surrounding atmosphere, thus creating an actual nuisance.

In buildings for this use it should not be considered that the cost of construction or cost of operation is the first requisite for such a building. The general health of the public should be considered first and above all other circumstances. The cost of maintenance of such buildings, as before described, will be considerably beyond the cost of those that are now constructed in some parts of the country, but the menace to the public health where the cheaply constructed buildings are used, is a constant dread at all time; therefore, I should recommend that for contagious diseases, buildings should be constructed with proper ventilating requirements, and so that they may be entirely fumigated and cleaned without any possibility of contamination.

DISCUSSION.

Mr. Barwick (supplemental remarks): I was called upon, a short while ago, to pass on a building of frame construction, one story, four single-bed wards, with a small ante-room, bathroom, etc. The only attempt at ventilation that was made in this building was by an 18x18-inch square register placed in the middle of the floor and a wooden box carried from that to pro-

vide fresh air; of course, it naturally would be cold air. For outward ventilation of the room, the ceiling was perforated with an 18-inch register connected with a galvanized iron pipe to the roof. That is one of the buildings that has been constructed recently. The older buildings have direct radiators in the ward which hold from 12 to 14 patients; there are large circular radiators placed here and there. I saw patients with scarlet fever, measles, typhoid fever, etc. I found they were in a pretty bad condition as far as ventilation went. It was not well provided for.

Mr. Gormly: I have not had an opportunity to read this paper very carefully. It might be of advantage to recommend a check in the ducts or flues, both in the exhaust and supply ducts, so that in case the ventilating machinery of a building of this kind breaks down, there would not be local air currents established which could carry disease germs from one ward to another. It would be a source of danger to have open ducts without any check against back-drafts in a building in which, at different times, contagious diseases are treated. That is one point which might be an improvement. A sterilizing plant should be installed for sterilizing dishes going from one room to another where patients are using these things. I think that would be another improvement. As to the water supply, attention is called to the fact that there shall be a water supply, both hot and cold, running into the rooms. It would be an improvement to place check-valves on the branches to each room. I have known of instances where the water supply was poor and disease germs were carried from one floor of the building to another. Suppose a patient was being bathed in an upper story. If the bath-tub supply pipe enters the tub submerged, and the pressure in the supply pipe is not great, an attendant attempting under like conditions to draw water in a lower story can siphon contaminated water into the supply pipes from the upper tub. Check-valves should be placed at each outlet in the supply pipes to prevent disease germs entering by siphonage. The drainage should be disinfected before being discharged. It might readily be done by having the sewage from the building run into a disinfecting tank before being discharged. There might be a recommendation made that all contagious-disease buildings

should be placed away from other buildings. I know that visitors to these buildings, mechanics going there to make repairs, doctors who are visiting and nurses who are going to and from the building, bring disease into the street-cars, the steam-cars, and also into the neighborhood. I know of an instance of that kind in our own city, where we have a municipal hospital for the treatment of contagious diseases, and in that immediate nighborhood almost all the diseases that are being treated in that hospital are to be found in the surrounding neighborhood, owing to the carelessness of the nurses and doctors and probably on account of the discharge of disease germs into the public sewers which are ventilated into the streets. I think a little care of that kind and a recommendation that all such buildings be placed away from all inhabited buildings would be desirable.

Mr. Carpenter: It is not quite plain to me whether Mr. Barwick means that the warm air and cold air should come through one duct, or whether he has two separate ducts—warm air from the heating apparatus and cold air from the fans.

Mr. Barwick: The air coming in would have a temperature of from 60 to 65 degrees and any additional heat that would be required beyond that would be arranged for as it passes through the stack at the foot of the flue, or by passing it around the stack, if the lower temperature was required. It is not absolutely necessary to bring cold air into a building unless you want to maintain that building very cold or bring down the temperature below 65. A building of that kind at 65 degrees in this district would be about right—75 is better in some cases, some people prefer 65. In one instance a doctor, I know, came into the room in which there was a case of measles; he found the room up to 75. (As a rule, with measles they try to keep the room warm and to prevent a draft). He was an old army surgeon. When he came in he said: "Throw down that window; we want fresh air right away."

Mr. Barron: It struck me that we don't design hospitals. Very few doctors ask for any advice from an engineer relative to heating and ventilating. They go to an architect, and he should go to a consulting engineer. He wants something definite: your province is to design an apparatus for that par-

ticular structure. We cannot idealize a building. You must take what comes from the doctor's and the architect's design.

In reference to the supply of air, having the hot-blast apparatus in the boiler-room outside of the hospital proper, blowing warm air into the hospital, is much superior to having indirect stacks in the hospital and having the air forced up into the registers. It seems to me that is proper. Bring the vitiated air by pipes to the boiler-room and force as much as you can into the boiler furnaces, forcing the rest into Mr. Barwick's uptake shaft. Hospitals have not much money to spend. If I was called on as a consulting engineer or as a contractor regarding the work of a hospital, I would look up where some gentleman had written a paper on the subject and had given the conclusions based on his experience. In that way a paper and the criticisms on a paper become valuable. I hope Mr. Jellett will discuss it, as I believe he has had some experience in hospital work.

Mr. Jellett: Mr. Barron assumes that I know something about hospitals; I may know something about them: I have had something to do with contagious diseases and many other kinds. I designed the plant for the Municipal Hospital in Philadelphia. At the time we took the measurements of the whole building, there were 360 odd cases of contagious diseases. It was a hazardous piece of engineering work. The men who did the measuring were wrapped in sheets and had to go through the disinfecting room before leaving the building. When the work was done, one wing of the hospital was vacated at a time and then another building vacated for two or three days, and the workmen allowed to go in. There were 130 cases of scarlet fever at the time. There were quite a number of cases of measles and other contagious diseases. Smallpox and diphtheria cases were in separate buildings. We have there a system of indirect stacks with tempering coils—the air being supplied by fans driven by electric motors. The arrangements are such that when there are 15 or 20 cases of contagious diseases the fans are run at a fixed speed; as the number of patients increases, the speed of the fans is increased; that is, the amount of air is regulated by the number of patients in the hospital, or sections of the hospital in use. The difficulty seems in most cities, they do not

build a hospital to meet the maximum conditions, as far as the building itself is concerned, equipment, electric lighting, etc. Municipal authorities do not appreciate the matter until an epidemic sets in; then, it is too late. At the present time, the discussion throughout the country is on smallpox; it reaches every large city in the United States to-day. I have looked over quite recently some of the reports submitted to the Board of Health of Philadelphia in connection with smallpox. It seems to have crept out all over the world, not only in this country, but abroad. To have a proper hospital ready is a very difficult thing to do. The expenditure to do it right is very considerable and it may remain idle for 20 years. The plant, when called upon under these conditions, is probably in bad condition. Naturally our municipal authorities should look upon the question of a municipal hospital as a preventive, as an insurance against trouble in the immediate neighborhood. We know how to plan a hospital and know even how to ventilate one, but we cannot impress on those who have the spending of the money the necessity for it. I have made plans for a number of hospitals for the treatment of consumption, which is classed to-day as a contagious disease. I have one in mind where there are 5 buildings and but one patient in each room. All private rooms—and all these rooms—face the south for the sun. The buildings are rather oddly constructed, so that the patient can always get the sun. The partitions between the different wards are made of expanded-metal lath, stiffened, and then plastered or cemented with a final hard-glaze finish; it is an enamel finish and the partitions finished are only 1½ inch thick. Each one of these rooms has an air supply with an indirect stack; each one of them has the old type of fire-place stove. These are in demand, as on a September morning, the consumptive patient suffers from moisture in the air and the stoves are called into use. The air supply is maintained all the time. This particular hospital has the corridor opening into the individual wards, and the utmost care is observed to see that there is no possibility of contamination from any building. A steam plant and separate power house in the rear of the building distribute the steam for heating through tunnels. The patients are never allowed in the basement. The tunnel is accessible only to the engineer

or possibly to the superintendent, but the nurses and doctors and other employees of the institution have no access to the tunnels or to the heating apparatus. Another one I have in mind, used for consumptives almost exclusively—called the Hospital for Incurables. In addition to the system I described, we have a down-draft system of ventilation, through a series of ducts through the basement. We utilize the blower for the forced-draft system under the boilers; we drive the contaminated air into the ash-pit through the fires and, in that way, dispose of any possibility of contamination. The whole question of how to properly equip a building for a contagious hospital with heating and ventilating is one I do not think we yet know much about. We know more than we have an opportunity to carry out. We have treated, in a number of instances, small contagious wards as an adjunct to a large hospital, but as a rule these are merely emergency plants. We have seen so much about contagious diseases in the newspapers lately, that any information that can be given by our members on this point should be given.

Mr. Kenrick: I would ask Mr. Barwick if he would not recommend a separate duct from each room to carry away the vitiated air?

Mr. Barwick: I would recommend a separate flue or a separate series of flues—a separate line of flues dropping down to the duct in the basement to be kept properly warm and in that way when the fan was running there would be very little chance of getting back air; but the dampers could be arranged so that they could be closed up in case the fan was not run. With reference to disinfecting the drainage, disinfectors are good and in the paper I spoke of ante-rooms. In these ante-rooms disinfectants could be placed so that the doctors in passing through the wards could use them. There could be disinfecting apparatus there so that the doctors could place in there their clothes and their instruments. The nurses going the same way would have to pass through the ante-room to get to any other portion of the building. As for dishes, that could be nicely done; they ought to be washed in the ward. It would be better if the drainage could be brought to a point and the refuse destroyed.

Mr. Kenrick: I would like to ask Mr. Barwick another ques-

tion. I understand him to say that he made examination of the building and that there was direct radiation; that a register, 18x18 in., connected with a wooden box, and an 18-in. register with a galvanized iron pipe leading out. Did Mr. Barwick take any reading with an anemometer, to see if there were any incoming or outgoing currents?

Mr. Barwick: I cannot answer that question, for the simple reason that the building was only at that time prospective; it was simply a building I was figuring on. I did not think it was the right thing to do—the idea of putting cold air directly in the middle of the room where you have one or two beds and then to stick a little bit of a vent register in the middle of the ceiling and run through the roof with a tin pipe—I think that was very poor ventilation for an architect to design.

Mr. Franklin: I would like to ask the gentleman who presented the paper one question; that is, if he would not find that, taking into consideration the element of cost, he would be able to construct a gravity apparatus that would meet the requirements quite successfully in a small building—a building that would take care of ten or a dozen patients.

Mr. Barwick: The main trouble is to get rid of the vitiated air, destroy the diseased germs carried through the air. In a case of that kind they could be burned by a series of gas jets. I had in mind in writing this paper a building that would take care of 75 or 100 patients. The cost of erecting buildings of this kind would be greater. I think there is considerable money spent foolishly in little buildings—money would be better spent in one large building; take such a case as they have in Brooklyn and Jersey City. In Jersey City they had a small pest-house built of frame. A short time ago somebody set fire to it; it went up in smoke that night; there were no occupants; but the next day there were two men taken; so they built a tent out of canvas and they brought from the different districts of the county 8 or 12 patients and placed them in beds in this tent. A strong breeze blew up and blew the roof off the tent. The poor fellows got wet and the nurses had to sit with umbrellas over them and put overcoats on them. They had a stove there and that set fire to the tent. Some of the occupants travelled over the hills in the rain. If they had had a proper building, properly constructed, heated and venti-

lated, they would not have had that trouble. In the small districts they would probably have to put up cottages of frame construction and burn the air through gas jets or small fires.

Mr. Kenrick: I would like to ask Mr. Franklin if it is not a fact that there has been an experiment tried in Boston of curing consumption by having parties live in tents in one of the quarters of Boston and that wholly on account of the purely fresh air it was successful.

Mr. Franklin: I understand there has been such a thing of the kind, but I am not acquainted with it.

Mr. Jellett: In connection with the hospitals for consumptives, one of these two hospitals I speak of had a doctor who had been treating cases by what was called the "new method." He startled them a short time ago by ordering open all the windows in the hospital—the temperature was 74 or 75. He had the patients wrapped up in blankets. The temperature dropped to 40 and the cold air blew through. There was a commotion among the board of directors and some other doctors objected. There is quite a discussion going on now with the doctors on this question. If you get into the pine forests in the mountains it may be all right, for you will find, as a rule, that the air there is dry. Some of the doctors decidedly object to this particular method of opening the windows. I had a discussion on the subject. I said: "Can't we have fresh air that is warm the same as if it is cold?" The answer was: "No." I said: "I don't agree with you." I think it is hard on a man's lungs to drop the temperature some 30 degrees in a few minutes. It must be a great strain on a man's system, assuming that he is a very sick man. I understand they take patients who could not sit up in bed, prop them up at an angle and throw open the windows. It is a question, of course, how far it is beneficial. Some contend that it is and some contend that it is not.

There is at the present time a hospital being built at White Haven, Pennsylvania, on the crest of the Blue Ridge, among the pines. There is one in New York where they use the fresh-air treatment in the pine forests. There are one or two in the South. These are all practically free hospitals. At the present time there is an organization in Philadelphia to build a contagious-diseases hospital for pay patients, so they can in-

sure better treatment—people who can pay a reasonable sum. I think that movement is likely to become general. There is great complaint of treatment in the contagious diseases in the municipal hospitals. It is very difficult to get proper attention to get the doctors and the necessary nurses in attendance, because there is no sufficient appropriation to maintain it and they do not contemplate that there will be more than a certain number go there. If you are called upon to plan a ventilating and heating system for a hospital for consumptives, you should first ascertain what the doctors are favorable to—cold or hot air.

Mr. Carpenter: Mr. Jellett has spoken of the hospital and some have spoken of the temperature required. I would say that the doctor at the hospital desired the building heated at 40 degrees and did not want it warmer at any time. They were delayed in the construction of the new building, so secured a barn and put in it a temporary heating arrangement. One day when I was there, the temperature in the shade, I should say, was below 40 degrees, but the patients being all convalescents were sitting on the sunny side of the barn, in steamer chairs, very much as you see on the deck of a steamer, wrapped in steamer rugs. There were in the neighborhood of twenty or thirty patients at the time. It was a regular barn, only a little more open than usual. The cracks on two sides of the barn—north and west—had been stopped up, leaving those on the south and east open. Up to that time there had been no windows placed, so they were having plenty of fresh air and were being benefited. The superintendent in charge was a young man who had made a study of this fresh-air treatment in the Alps and elsewhere and was applying it here.

XCIV.

THE TEMPORARY WARMING OF THE LARGE HALL OF THE ROYAL AND IMPERIAL PALACE LIBRARY, VIENNA, AUSTRIA, FOR THE VISIT OF HIS IMPERIAL HIGHNESS, THE CROWN PRINCE OF GERMANY, APRIL 14, 1901.

BY PROF. EDWARD METER, OF THE IMPERIAL TECHNICAL HIGH SCHOOL, VIENNA,

TRANSLATED FROM THE GERMAN BY CHARLES F. HAUSS.

(Member of the Society.)

The subject that I am about to submit to you to-day may not be of very great importance and may not occur under the same conditions again, yet it seems to me to be so unusual owing to the peculiar conditions and method of handling as to be worthy of your attention.

The hall is the large bookroom of the Imperial Court Library, designed by Court Architect Fischer von Erlbach, and finished about 1736. The walls are all covered with costly shelving made of rare woods, and filled with priceless books and manuscripts, the ceiling is beautifully frescoed, and the floor is made of mighty slabs of stone.

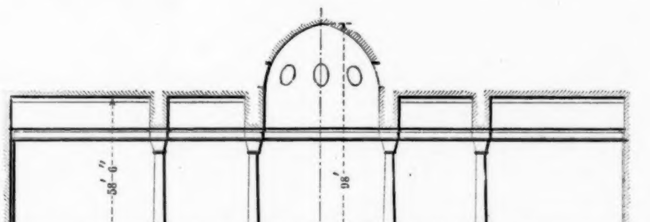
This hall had never been artificially warmed in its nearly 200 years of existence, and when you know that the order to heat it came only a few days before the intended reception, and during the cold season of the year, for such a select gathering, you will have some idea of the task set for us.

Figs. 1 and 2 show a sectional elevation and plan of the hall. It was a sudden idea of the Court Marshal, placed in the front rank of the programme, that the Austrian Emperor should lead his young and ambitious guest, Germany's Crown Prince, through the grand library hall to show him some of his priceless treasures. Naturally, a great deal of thought was given to properly carry out this idea.

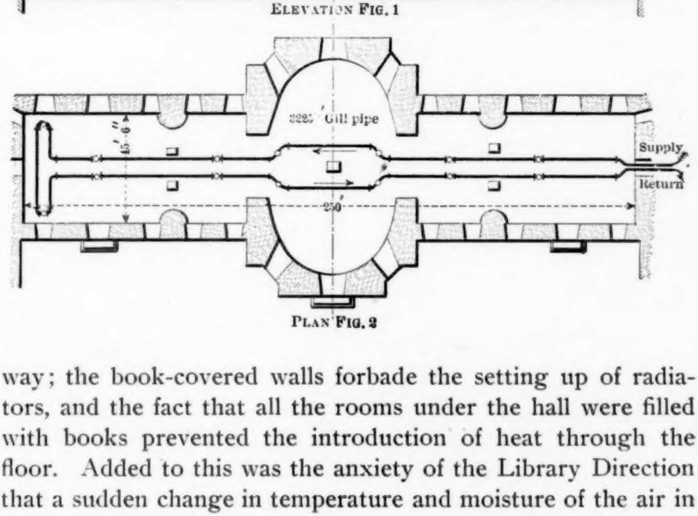
The greatest difficulty was to install the heating apparatus, the order for which was given about the end of March. The weather was cool and variable, and the reception was to take place on April 14th.

Now we knew that in former years the hall seldom had a temperature of 50 degrees Fahrenheit even in May, when the attendants entered it wearing overcoats.

A personal survey showed at once the many difficulties in the



ELEVATION FIG. 1



PLAN FIG. 2

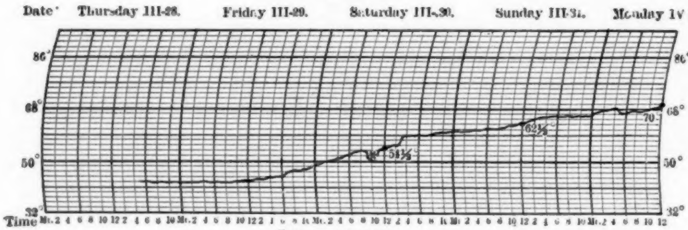
way; the book-covered walls forbade the setting up of radiators, and the fact that all the rooms under the hall were filled with books prevented the introduction of heat through the floor. Added to this was the anxiety of the Library Direction that a sudden change in temperature and moisture of the air in the hall might have a bad effect on the woodwork, books, and bindings, which was anything but encouraging, and urged on us the greatest care. There was no thought of erecting a permanent heating apparatus, owing especially to the lack of time.

One help in the solution of the problem lay in the fact that the end of a steam main that is part of the system for heating the

new palace was not far away, and allowed us, with slight changes, to get steam at 39 lbs. pressure. The method of using this steam was not long in doubt, for the first thing to impress the expert was the large stone floor space, with which the body must come in close contact.

Fifteen minutes on this floor was enough to give one very

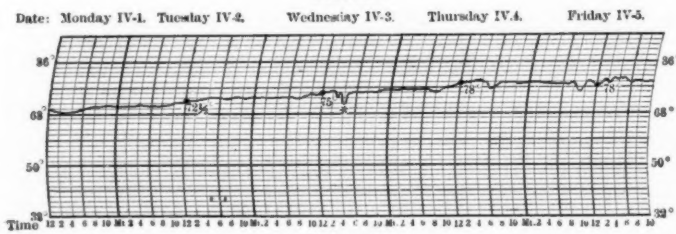
FIGURE 3



cold feet, which great loss of bodily heat necessitated the giving of special attention to warming the floor.

This prompted the decision to distribute the heating surfaces as near the floor as possible, and through the middle of the hall—and by a continuous heating of the space, have the surrounding walls and floor absorb enough heat and store it,

FIGURE 4



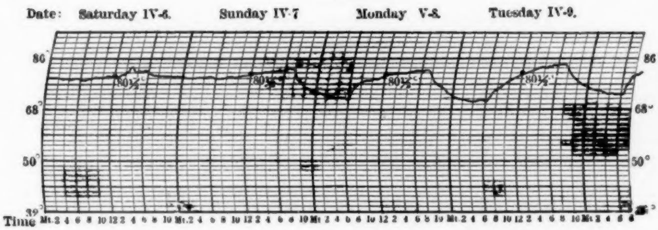
that they would give it off again after the apparatus was removed, and leave the space warm enough on the day of the reception to make it safe for the Imperial guest to spend some time in the hall.

For removing the heating apparatus, airing, and decorating the hall, three days were allowed, and it was determined that

the temperature should at no time exceed 82.4 degrees Fahrenheit, and that the usual relative amount of moisture in the air should be maintained.

The construction of the apparatus was intrusted to the firm of J. L. Bacon, in Vienna, and little time was lost before work was commenced. The amount of heat necessary to maintain

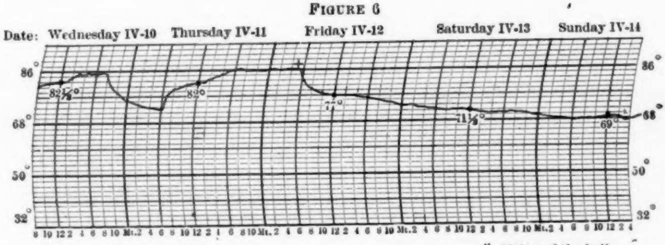
FIGURE 5



NOTE. The Temperature marked inside the diagrams is the temperature at 12 o'clock noon of each day.

a temperature of 59 degrees Fahrenheit in the hall, when the outside temperature was 41 degrees Fahrenheit, was about 600,000 heat units per hour. The amount of radiation used in the work was 3,225 square feet of gill pipe, or extended surface radiation, rated to give off about 800,000 B. T. U. per hour. The pipe was laid in two lines, as near the floor as possible, to

FIGURE 6



+ End of period of heating

* Airing of the hall.

allow for drainage in the two lines, which are together about 500 feet long. These gill pipes are shown in Fig. 8. The work was finished in the short space of three days and on 28th day of March at 5 P. M., steam was turned on.

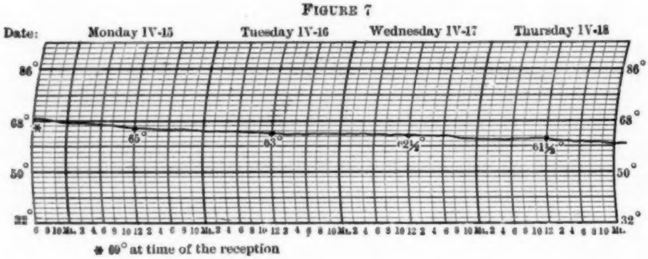
The heat was maintained continuously day and night until

April 7, after which, the temperature having reached the limit of 82 degrees Fahrenheit, the heat was only maintained for 12 hours each day.

At 6 o'clock A. M. on April 12th the heating apparatus was removed, and at 3 o'clock P. M. on April 14th, or three hours before the reception, the doors and windows were opened to thoroughly air the hall.

The record of temperature was kept by two registering ther-

FIGURE 7



mometers, one on the floor, the other in the gallery. Figs. 3 to 7 show the record of the gallery thermometer.

It may be well to mark the rapid rise in temperature, from the beginning of the time of heating—up to 69.8 degrees Fahrenheit—and the much slower drop in temperature after the heat was shut off. Yet the increase as well as the decrease was gradual, and show that the walls and floor did store the heat.

FIG. 8.—CAST-IRON GILL-PIPE RADIATION USED.

The sections are 6 ft. 6 in. long, with flanges, and have 42 square feet of surface per section.

The diagram shows that on the day of the reception the inside temperature was about 68 degrees Fahrenheit. The average outside temperature was 47.3 degrees Fahrenheit. It is remarkable that the floor thermometer registered during the first period of heating from 2.2 degrees to 3.6 degrees Fahrenheit higher than the gallery thermometer.

Aside from the observation of the space temperatures we

also made tests of the floor temperatures with quicksilver thermometers, that were set in bored holes 2¾ inches deep. This record is shown in Fig. 9, which shows also the relative position

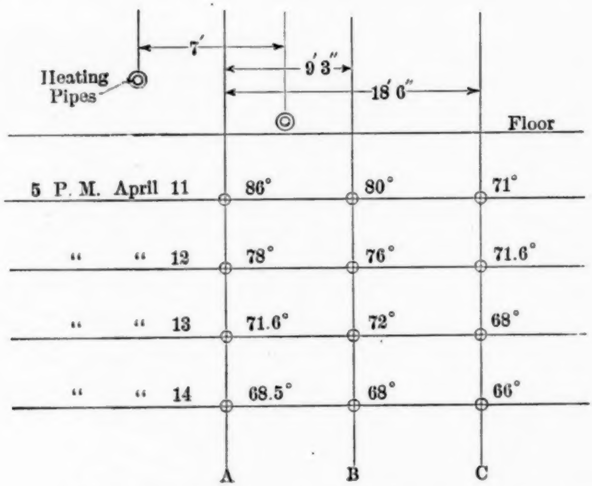


FIG. 9.—SHOWING RECORD OF FLOOR TEMPERATURES.

The heating pipes were placed 7 feet apart. The vertical line A is the thermometer between the pipes, line B the one 9′ 3″ from centre, and line C the one placed 18′ 6″ from centre of radiation.

of the heating pipes and the position of the floor thermometers.

When heating was commenced, with an inside temperature of 42.8 degrees Fahrenheit, a relative moisture of 70 per cent. was contained in the air, which percentage was maintained throughout by 14 tin funnels filled with pebbles and attached with regulating valves to the steam pipes, and through which steam was allowed to escape. Fig. 10 shows this air moistener.

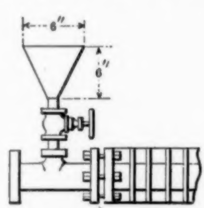


FIG. 10.—AIR MOISTENER.

A 6 in. by 6 in. tin funnel filled with pebbles, through which the steam from a half-inch valve is allowed to reach the air.

The success of the arrangement was complete, the hall was heated to the proper temperature at the time of the reception, and there was no injury to either woodwork or books.

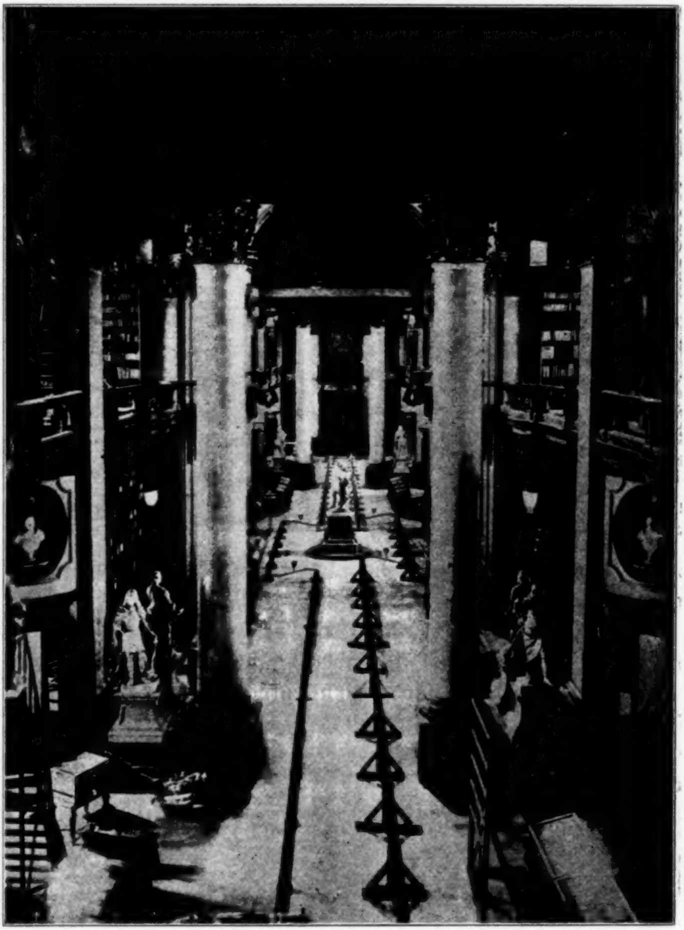


FIG. 11.—INTERIOR VIEW OF THE IMPERIAL COURT LIBRARY IN VIENNA.

Fig. 11 shows an interior view of the hall when the heating apparatus was in, and gives a good idea of the general conditions.

DISCUSSION.

The President: You have heard the paper. Any discussion?

Mr. Wolfe: I move you that he be thanked for the presentation of this paper. (Seconded.)

The President: I think that motion is out of order under our rules and by-laws. We are not allowed to thank a member for a paper. Any discussion?

Mr. Kent: We should not allow this paper to pass without some expression of our appreciation of it. It is an admirable paper, showing a new problem and describing it so briefly and accurately, so that any one can follow it and reproduce this kind of heating if ever desirable. It shows how carefully German engineers go to work on such a problem, showing enterprise and love of work which would be a credit to any Yankee engineer. I am very glad to get it.

Mr. Barron: I think we should take this as a model for the papers presented every year. It is thoroughly practical and scientific. It bears accuracy on the face. One who is reading it believes he is reading about one who knows what he is doing.

XCV.

DEPRECIATION, MAINTENANCE AND INTEREST CHARGES.

BY REGINALD PELHAM BOLTON.

(Member of the Society.)

The comparison of certain different apparatus, the relative economy of competing devices and the value of improvements, are affected directly by the empirical amounts chargeable against them as interest, maintenance and depreciation.

A common and very crude method appears to be to fix each item in such computations at a rate of 5 per cent. In the course of discussions with representatives of power and heat supply companies desirous of applying their systems to certain buildings, I have been confronted with an assertion that depreciation alone should be charged on independent power and heating plants at the rate of 8 per cent., and that interest should be charged upon the whole cost of the installation at the rate of 5 per cent., additional to maintenance at 5 per cent. I have as a result of these varying and apparently haphazard figures been led to make some inquiry into this question, and venture to think some conclusions gained from New York circumstances will be of interest to members of a society especially connected with the design and installation of operating machinery and appliances necessary to life and comfort.

INTEREST.

In the city of New York the rates of interest on borrowed money vary of course with the nature of the security. In the case of buildings and factories the form of security is commonly a mortgage. First mortgages are usually obtainable up to 60 per cent. of the value of the property, and in Manhattan Island at present, a rate of interest of 4 per cent. can be ob-

tained, or in certain centrally situated properties one-half of one per cent. lower.

The value of some land is so great that a sixty per cent. mortgage upon its value will suffice to erect and equip a very considerable building upon it, but where this is not the case, an owner borrowing six-tenths of the cost of his building on first mortgage may borrow the balance, if he be in good credit, at as low as 5 per cent., of banks, on note, bond or second mortgage.

In a close computation therefore, it should be ascertained what rate of interest the money represented by a plant involves, but where the information is not obtainable it may be assumed that the rate of interest does not exceed 4 per cent. on $\frac{6}{10}$ and 5 per cent. on $\frac{4}{10}$, or a mean of $4\frac{4}{10}$ per cent.

MAINTENANCE.

This is compounded of several elements. Cost of upkeep, replacement and precautionary measures. A reasonable amount of care must be assumed in keeping the apparatus in operating condition. Replacement provides for renewal of working parts, and painting of perishable or exposed material. Renewal of inherently renewable materials such as packing come under this heading. By precautionary measures I understand all such steps as require to be taken in good time to obviate in advance the effects of age or decay.

Naturally such items vary very considerably with all kinds of apparatus, and must be taken into separate consideration.

The cost of maintenance, therefore, varies too widely to be stated as a fixed element, but must be estimated for different apparatus by the results of experience and careful foresight. In a very general way one and a half per cent. on the prime cost of a heating and ventilating plant should suffice to cover the above items and on operating machinery 2 to 4 per cent. according to conditions.

Repairs, assuming the term to deal only with accidental damage or breakage or discovery of defects, can be properly covered by insurance or by civil suit, and if not, are to be assumed as an unknown risk. They are not a part of maintenance.

DEPRECIATION.

This is a charge which is calculated to represent the gradual deterioration of a plant, resulting in its eventual wearing out. In certain cases it has been assumed also to represent the superannuation of a plant, or in other words its loss of competitive power by reason of the advent of improved appliances.

In a general way I consider both these elements are overestimated. It is common to have a sweeping limit of ten or fifteen years assigned as the life of a plant, on one or other of the above grounds. While the policy of clinging to antiquated and unproductive machinery is not in consonance with modern ideas of profitable operation and is not here recommended, it must be pointed out that it is not an argument against assigning a reasonably long life to any apparatus, that its use may be found sooner or later to be less economical than improved apparatus. Such improved appliances will, if sufficiently economical, justify in their results the entire renewal of the existing plant at an earlier date than assigned to it, and the cost of such extinguishment or partial discontinuance is to be borne by or to become chargeable against the results attainable with the improved plant.

New methods may come into existence at any time and cannot be reckoned with as a fixed element in computing the useful life of any apparatus.

Again, the possibilities of remodeling are, in the case of such apparatus as the members of this Society are concerned in, very often capable of renewing the life of the perishable portions of installations.

Experience in the remodeling of old plants goes to show that even in such machinery as was built a quarter of a century ago, the life of rotating machinery is greater than twenty years, while in boilers of the water tube type, piping chimneys, and much of similar apparatus, it may be taken at twenty-five years. Pumping and hoisting machinery of similar age is quite common, in all cases assuming reasonable care and reasonable renewals for which, as before asserted, separate charges are, of course, to be made.

From the above considerations it may be gathered that in the

case of a modern private commercial power or heating plant an assumed life of from fifteen to twenty-five years, varying with the nature of the appliances, is proper, and for the purpose of ready calculation a mean of twenty-one years can safely be taken.

It is not to be supposed that an owner will regularly lay by annually a sum equal to the amount charged as depreciation, or take the trouble to arrange for its investment and the investment of its interest. It would not, in fact, pay him to do so, because the money is worth more to him in his own business than he could obtain at current rates in the market or savings banks. In practice it is therefore retained in his business or investments, and is earning the rate of interest obtainable therein. In a majority of instances where the business in which the machinery is employed is an actively constructive or manufacturing one, the assumed amount of depreciation is really earning very high rates of interest, often more than 25 per cent. per annum. Under not uncommon commercial circumstances therefore, the assumed depreciation fund may very moderately be credited with an earning capacity of ten per cent. compound interest. With a life of twenty-one years and a rate of compound interest of ten per cent. the charge of depreciation becomes only one and one half per cent. upon the capital outlay.

It will be evident how important is the consideration of these standing charges in deciding the relative economy of machinery, but it is seldom that they are properly applied. We often learn of the adoption of apparatus designed to effect a certain economy, the cost of which, if debited with its proper charges, would outweigh the ascertained economy, and which is therefore being operated at a loss. This is particularly the case in the numerous devices for coal saving in boilers, and guarantees of a certain result are apt to be considerably counterbalanced if the proper charges are applied.

An illustration may be taken from a case recently considered in detail.

A high-duty pumping-plant was offered for a large elevator service with a guaranteed saving of 15 lbs. of steam per horse power of water pumped per hour. Careful estimates showed a probable saving in fuel of $1,500 per annum by this apparatus, the additional cost of which amounted, however, to $19,000.

In case the life of the two pumps involved is taken at 20 years, and the rates of interest are as herein stated, the extra capital outlay is to be charged with

Interest, $4\frac{4}{10}$ per cent	$836
Depreciation, $1\frac{1}{2}$ per cent	285
Maintenance, 3 per cent	570
Additional Oil	70
	$1,761

showing that the pumps will be run at a loss of $261 per annum, which capitalized at $4\frac{4}{10}$ per cent. represents a sum of nearly $6,000. By applying the charges to the saving guaranteed it will be seen that the saving justifies only a capital outlay of $16,780. Therefore to show any gain the cost of the improvement must be less than that figure.

DISCUSSION.

Mr. Kent: I think this paper is a step in the right direction in making careful estimates. The author has not gone far enough. In the discussion of the subject of interest, it is all right for New York conditions. For maintenance he has allowed too much, and also for depreciation. In the table on page 5, he figures up depreciation $1\frac{1}{2}$ per cent. and maintenance 3 per cent. That was on a high-duty pumping plant costing $19,000. It is scarcely conceivable that the figures are correct. Another statement, that the life of a pumping engine, under reasonable care and renewals, is not more than fifteen or twenty years. I think the average life of a good pumping engine will not be less than fifty years. If we change from 3 to $1\frac{1}{2}$ per cent., it will make the charge for maintenance $285 instead of $570, and the pumps, instead of running at a loss of $260 per annum, will show a gain of $24. So the whole argument could be reversed by a little change in these items.

The interest charge—what he says about interest here is based on his knowledge of certain facts. What he states about maintenance and depreciation are guesses, and they are the averages of a great variety of uncertain conditions; I think

he has guessed too high. He says: "The life of rotating machinery is greater than twenty years." Here he is correct. "Boilers may be taken at twenty-five years." Boilers of other types, such as the old shell type, are in use to-day, forty years old. The average of the ordinary boiler is more than twenty-five years. If you do not give it bad water, and keep it in good condition, it surely averages more than twenty-five years in this country. Steam piping in buildings should have a much longer life than twenty-five years. Cast iron radiators should have a reasonable life of a hundred years, except the wrought iron nipples. The chimneys, if built of brick, should live as long as the building; the average of twenty-five years is entirely too small. Rapid-speed machinery is rather short lived. I am referring to cases where people are willing to spend $19,000 for improved slow running machinery, like high-class pumping engines.

Mr. Gormly: I have in my pocket a sample of two pieces of pipe in use seven years in a dwelling house—low-pressure steam—and you can look right through them in various places. I should like to pass them around. This appears to be steel tubing used with cast-iron radiators and fittings and brass valves. It looks as though a portion of the pipe on the bottom has been eaten out by water or distilled steam; it does not seem to be friction.

Mr. Kenrick: Mr. Bolton speaks of the rate of interest on borrowed money. Does he mean on a building already constructed or in process of construction? If he means construction alone I think if he came from Massachusetts he would have a hard time to borrow money at 4 per cent. He would have to pay 5, 5½ and 6.

The President: Any further discussion?

Mr. Blackmore: I think these figures are comparative, and given to draw attention to the fact that most owners of plants are figuring too much for maintenance and depreciation. The cost of maintenance is very great, even on a small plant. A great deal depends on what items are given as cost of maintenance. There is no regular rule on the subject. Some owners of plants will charge up every item of repairs and a great many things in the expense account. Others, again, will charge only actual outlay for replacing new parts, replacing

packing and things of that kind. Therefore, with such a wide variation in ideas it is not possible to prepare a paper of this kind that is not open to criticism. I think it is wise, however, to publish a paper of this kind, inasmuch as it draws the attention of the members to the subject.

XCVI.

AN INVESTIGATION INTO THE DIFFERENCE BETWEEN THE COEFFICIENTS FOR THE THERMAL CONDUCTIVITY OF BUILDING MATERIALS, OBTAINED BY PÉCLET, AND THOSE OBTAINED BY LATER EXPERIMENTERS.

BY A. B. RECK

(Member of the Society, Copenhagen, Denmark.)

There have, of late, now and again, arisen doubts about the reliability of the coefficients for the thermal conductivity of the different building materials, obtained by Péclet, the great French natural philosopher, who lived in the first part of the past century. Knowledge of the real magnitude of these coefficients is indispensable for the exact estimation of how much heating surface will be necessary in radiators, boilers, and other parts of heating apparatus for keeping the temperature of the interiors of buildings at a certain point. I have, therefore, for my own satisfaction, examined what has been published in different scientific journals concerning later experiments for obtaining the thermal conductivity of building materials, and I think that the result of my researches will not be without interest to other engineers.

Péclet's experiments with what he calls poor conductors (to distinguish them from the metals), are fully described in "Péclet, Traité de la Chaleur," IV édition, Tome I, pages 542 to 555. For those who do not own this treatise, or have no opportunity of reading it, I mention that the experiments are, as far as I know, also described in "Annales de Chim. et Physique," III sér, vol. 2, and n "Pogg. Annalen Bd. 55, 1842," which can, no doubt, be had in most scientific libraries. It has been mentioned that one cannot rely upon these, Péclet's, experiments with poor heat conductors, because the results of his experiments with good heat conductors, viz.: metals,

proved to be too low in comparsion with what is now known through the corresponding experiments made by the Swede Ångström, the Dane Lorenz and others. The Englishman Lees has, however, in his undernamed essay, shown that the only reason for Péclet's low numbers for metals probably is, that he, during his experiments, did not get the water renewed sufficiently quickly on the very surfaces of the plates he experimented with. Lees thinks that this circumstance has most likely been of some consequence in the experiments with the metals, through which the heat passes rapidly, while it can only have had very little importance in the experiments with the building materials which have proportionally much less conductivity for heat (on an average less than 1/100 of that of metals). Among later experiments, which directly confirm Péclet's experiments with building materials, we must, first of all, refer to those of Professor C. Christiansen (at present at Copenhagen University), as they are described in "Wiedemann's Annalen, Bd. 14, 1881," page 23 and following. Professor Christiansen communicates here that he has determined the thermal conductivity for glass and marble to be respectively 38 and 120 times that of air. As the coefficient of conductivity of air, in the ordinary $\left(\frac{\text{grm.}}{\text{cm. sec.}}\right)$ units, has been accurately determined to be about 0.0000525 ("Grätz Wiedemann's Annalen," 1881, Bd. 14, and "Winkelmann Pogg. Ann.," Bd. 157 and 159) the coefficients of glass and marble become, according to Christiansen, respectively 0.0020 and 0.0063 in $\left(\frac{\text{grm.}}{\text{cm. sec.}}\right)$ units. Péclet specifies the thermal conductivity of glass and white marble in $\left(\frac{\text{Kilgr.}}{\text{meter hour}}\right)$ units usually employed by heating engineers, to be respectively 0.75 and 2.78, numbers which, through division by 360, being reduced to $\left(\frac{\text{gr.}}{\text{cm. sec.}}\right)$ units, give 0.0021 and 0.0077, which differ but slightly from those derived from Professor Christiansen's experiments.

Péclet comes still nearer to the experiments made by C. H. Lees with the same materials, glass and marble, described in "Phil. Transactions of the Royal Society in London," Vol. 183.

for 1892. In a manner quite different from both Péclet's and Christiansen's, and by extraordinarily well-executed experiments, Lees determines the coefficients in $\left(\frac{\text{gr.}}{\text{cm. sec.}}\right)$ units for flint glass and white marble as, respectively, 0.002 and 0.0071, which prove to be still nearer Péclet's than Professor Christiansen's numbers.

It ought to be noted here that Lees has also made experiments with several materials less hard than the above mentioned, such as flannel, silk, paper and the like. The correctness of these last experiments may, however, be very doubtful, as the insignificant thickness of the layers chosen for these materials, (1/10 to ½ mm.), under such a compression as is employed in the experiments, cannot very likely be supposed to give results which directly could be applied to practice. Therefore, as long as Lees' experiments with the materials in question are not confirmed by experiments with thicker layers, there seems to be no reason to reject Péclet's numbers.

We now come to a list of coefficients of conductivity found in the well-known German treatise "Handbuch der Architektur," III Teil, IV Bd., page 101. This list begins with a group of different experimenters' coefficients for tranquil air, among which is one ascribed to Péclet, which is now known to be about twice as great as the real one. To this it must, however, be remarked that Péclet, as is evident from his own treatise, has not made any direct experiments on the conductivity of air and that he has not either taken any coefficient for air into his lists, but only expressed the *supposition* that air may have the same conductivity as textile materials. This supposition has assuredly been proved not to agree with what has been discovered later on, but this mistake is of course no sufficient reason for having less confidence in Péclet's experiments themselves. In the above mentioned list, as to the coefficients for poor heat conductors, besides Péclet's numbers, there are quoted a series of numbers due to the physical philosopher Forbes, which are all considerably lower than Péclet's. It is, however, far from difficult to point out the reason for the very low results obtained by Forbes in comparison with those of all others. Thus, Lees, in his treatise previously referred to, points out that Forbes absorbed the heat by a freezing mixture,

and simply took it for granted that the temperature of this mixture was the same directly on the plates as in the centre of the mixture, where the ball of the thermometer had its place. Lees shows that this supposition is entirely wrong, and that the results of Forbes's experiments, in consequence, are most unreliable.

What else is shown in the list of the "Handbook of Architecture" concerning the difference between Péclet's and others' numbers with respect to metals, is, with reference to what has been said in the preceding about Pèclet's method of experiments, nothing else but what one in advance knows the reasons of, and cannot lessen the importance of his numbers for building materials. Two of these numbers, viz.: those for glass and marble, are, as shown in the preceding, irrefutably established as essentially right by Professor Christiansen's and Lees's examinations, made by each of them in a manner entirely different from Péclet's. This ought to be sufficient to enable us to take it for granted that Péclet's numbers for building materials are sufficiently correct for practice.

A few of these numbers, besides those for glass and marble, are verified by the experiments of others. Such is the case with the coefficients obtained by Péclet, for walnut- and oak-wood, at right angles with the fibres. The fact is that the above-mentioned Englishman, Lees, has examined the thermal conductivity of the first named wood and found the coefficient in $\left(\frac{\text{cm.. sec.}}{\text{gr.}}\right)$ units to be 0.00036, while Péclet's coefficient in the same units is 0.00029. Moreover the German Less (see "Poggendorff's Annalen," Erg. 8, 1878), compared oak-wood, at right angles with the fibres, with best conducting marble, and stated that the ratio between the two coefficients for conduction of heat is 0.075. By taking the ratio between the same two numbers at Pèclet's, the number of the ratio becomes 0.057. Such deviations are not so great that they could not easily be explained by the difference of the tested samples.

Through what has been said above, it is considered to be proved that, if the great majority of heating engineers have hitherto taken Péclet's experiments on the thermal conductivity of building materials as a basis, they have stood on completely scientific ground.

We quote, therefore, in the following the most important numbers obtained by Péclet, in French and in English units:

Coefficients (C) for thermal conductivity of some poor heat conductors obtained by Péclet.

Material.	(1) Metric Units.	(2) English Units.
Grey marble, fine-grained	3.48	28.0
White marble, coarse-grained	2.78	22.5
Lime-stone, fine-grained (mean of three samples)	1.82	14.8
Lime-stone, coarse-grained (mean of two samples)	1.3	10.5
Plaster of Paris	0.44	3.6
Brick	0.69	5.6
Powdered Brick, coarse-grained	0.139	1.1
Fir at right angles to the fibres	0.093	0.75
Fir, parallel with fibres	0.17	1.4
Walnut at right angles to the fibres	0.103	0.83
Walnut, parallel with fibres	0.174	1.4
Cork	0.143	1.15
Glass	0.75	6.0
Sand	0.27	2.2
Wood-ashes	0.06	0.5
Powdered Charcoal	0.079	0.65
Powdered Coke	0.160	1.3
Cotton, raw or woven	0.040	0.32
Paper	0.034	0.27

The first column of numbers indicates how many calories (in Kilgr. and ° C.) will, in an hour, pass through a layer of the material one square meter in area and one meter thick, when the difference in temperature between the two sides of the material is one degree Celsius. The second column indicates how many heat units (in lbs. and ° F.) will, in an hour, pass through a layer of the same material, one square foot in area and one inch thick, when the difference in temperature between the two sides is one degree Fahrenheit.

As to the coefficients found by Dulong and Petit, as well as by Péclet for the transfer of heat respectively by radiation and convection in quiet air, there has not, as far as I know, been published anything overthrowing the essential correctness of these coefficients. Not even in the question about the influence of the velocity of air on the coefficients for convection are we without a solid base of intelligibly described experiments undertaken in a scientific manner. To this side of the whole question I hope to get an opportunity of referring again at a later period.

Finally, concerning the formula in which all these coefficients are applicable, I have not, in the nearly 25 years in which I have followed as well as possible the literature on the trans-

mission of heat, met with a single successful attack on the main formula, which, since Péclet, continues to reappear, in different forms, but in reality always the same, as fully acknowledged by every physical philosopher of authority, namely:

$$\frac{1}{Q} = \frac{1}{r + f} + \frac{e}{C} + \frac{1}{r' + f'}$$

where Q indicates the heat units for one unit of surface that will pass a wall for each degree of difference of temperature between the inner and outer surroundings of the wall, e is the thickness of the wall, C is the coefficient for the thermal conductivity of the material (which can be taken from the above list), r and f are the coefficients for the transfer of heat for one unit of surface, respectively by radiation and convection for the outer surface of the wall, while r' and f' indicate the coefficients for the absorption of heat for one unit of surface, respectively, by radiation and convection for the inner surface.

If there now is asked, what use the heating engineer can have of employing the above-named formula, the answer will be given through the following example, which shows the difference it makes if a wall of the same material and thickness is under conditions more or less favorable for the transmission of heat.

Thus, suppose, that we, in one case, have a 9-in. wall which, besides being an outer wall of a room (whose other walls are all inner walls), is situated in an entirely unprotected part of a building; suppose, in another case, that we have an equally thick wall forming the outer wall of a room (which has another outer wall just opposite) and facing a yard wholly surrounded by other buildings and thus protected against wind. Then it will be seen, that in the first case, for the coefficients r, f, and r' in the formula, maximum values are to be employed, while in the other case minimum values ought to be used. The calculation of Q with the help of the formula, whose correctness is beyond doubt, will then show, that in the first case nearly twice as much heat will be transmitted through a wall of the described thickness as in the other case.

Even older and experienced engineers, who, in the case of ordinary buildings, never make mistakes in the calculation of the heating surfaces required, will, therefore, at any rate in

many special cases, have advantage in employing the exact formula for transmission of heat. Younger engineers will, in the first years of their practical work, do well in employing it for all their installations. They will thereby avoid inconveniences occasioned by mistakes and, at the same time, save money for themselves or their employers.

For those who will not take the trouble of studying the more complete French or German treatises on heating theories, Professor J. H. Kinealy's little book "Formulas and Tables for Heating," New York, 1899, will be an excellent help.

In other branches of engineering, for instance when a steam engine or a bridge is wanted, everybody knows that one ought to apply to men who are thoroughly acquainted with the scientific principles according to which such things are constructed, if the best is to be obtained for the money at disposal.

In heating, it ought to come so far that those who build houses understand that we heating engineers as well as other engineers, can make our calculations on a perfectly reliable scientific basis, and that for this reason, our co-operation for the determination of the dimensions of the different parts of a heating installation is indispensable, if satisfactory results are to be obtained without the expenses becoming larger than necessary.

XCVII.

LOSS OF HEAT THROUGH WALLS OF BUILDINGS (DISCUSSION OF PAPER BY A. B. RECK, OF COPENHAGEN, MEMBER OF THE SOCIETY).

BY R. C. CARPENTER.

There seem to be various and contradictory values given in scientific literature for the coefficients of thermal conductivity. This fact is referred to by Sir Wm. Thomson in the article on Heat in the Encyclopædia Britannica, and also in the noted work by Thomas Preston on the Theory of Heat.

TABLE OF COEFFICIENTS OF CONDUCTIVITY FROM PÉCLET PER DEGREE CENTIGRADE PER HOUR.

Kind of Material.	Calories per square metre, one metre thick.	British Thermal units per square foot, one inch thick.
Gray marble, fine grained	3.48	28.0
White marble, coarse grained	2.78	22.5
Limestone, fine grained (mean of 3 samples)	1.82	14.8
" coarse " (" 2 ")	1.3	10.5
Plaster of Paris	0.44	3.6
Brick	0.69	5.6
" powdered, coarse grained.	0.189	1.1
Fir, right angles to fibres	0.093	0.75
" parallel to fibres.	0.17	1.4
Walnut, perpendicular to fibres	0.103	0.83
" parallel to fibres	0.174	1.4
Cork	0.143	1.15
Glass.	0.75	6.00
Sand	0.27	2.2
Wood ashes	0.06	0.5
Powdered charcoal	0.079	0.65
Powdered coke	0.160	1.30
Cotton, raw or woven	0.040	0.32
Paper,	0.034	0.27

As an illustration, the values for the heat conductivity of copper were stated by early authorities as follows, when reduced to units of heat expressed in calories transmitted per second and per square centimetre per centigrade degree difference of temperature for 1 centimetre of thickness (commonly called C. G. S. units):

	Calories.	B. T. U.
By Clement	.0057	2.5
" Péclet	0.178	77.5
" Ängstrom	1.1	489.2
Corrected recent values	0.91	396.4

(The figures in the last column are the results reduced to B. T. U. transmitted per square foot per hour per degree difference of temperature per one foot in thickness by multiplying by 435.6.)

From this statement it would seem that Péclet's value for conductivity of copper was about one-fifth of the correct value. This error was due to an improper method of performing his experiment.

The coefficients of heat transmission for poor conductors has doubtless also been stated in various ways, although for such materials the values given by Péclet seem to have been substantially correct; in fact, so far as I can find out, Péclet is the only investigator who has systematically made experiments of the heat conductivity of building materials. Some of his results have been checked by Forbes, Sir W. Thomson and J. T. Bottomley in recent years by better methods and show substantial agreement.

Various German authorities have given this matter consideration, but so far as I can ascertain their results are all based on the values obtained in the experiments by Péclet. Prof. J. H. Kinealy has translated and transformed into American units the best German practice in a book entitled Formulas and Tables for Heating, published by David Williams Co., New York.

Summing the whole matter up, it would seem that the principal reliable experiments that we have for the thermal conductivity of building materials are due to Péclet.

The formula for heat transmission for which Mr. Reck seems inclined to give credit to Péclet was probably first stated by Fourier. This formula as given by Péclet is as follows:

For a single plate of unit area

$$M = \frac{C\ (t - t')}{e}$$

in which

M = the heat transmitted, e the thickness, t and t′ the temperature of the two sides of the plates (not the tempera-

ture of the medium adjacent to the plates, but of the material itself), C the coefficient of conductivity.

For two plates, each of unit area and with inner faces in contact, if x is the temperature of the inner face, e′ the thickness of the second plate and C′ its conductivity, we have

$$M = \frac{C\ (t - x)}{e} \qquad M = \frac{C'\ (x - t')}{e'}$$

from which, by eliminating x

$$M = \frac{t - t'}{\frac{e}{c} + \frac{e'}{c'}}.$$

If there are several plates in contact, each with different coefficients of conductivity and each of different thickness, we should have the following as the value for the heat transmitted:

$$M = (t - t') : \left(\frac{e}{C} + \frac{e'}{C'} + \frac{c''}{C''} + \text{etc.}\right).$$

From the above formula the heat transmission could be easily computed provided one knew the temperature of the surfaces of the bodies, but Péclet states truly that these can never be known exactly, as they can only be determined by very delicate experiments which are impossible in practice. For these reasons it is necessary to obtain formulas in which the values are given in terms of the temperature of the air in contact with the surfaces.

The value of C for various poor conducting substances is given in the original text of Péclet as in the first column of the accompanying table, which is copied from the paper of A. B. Reck, referred to.

The following determinations are selected from various authorities and agree closely with the results obtained by Péclet for poor conducting materials:

TABLE OF COEFFICIENT OF CONDUCTIVITY FROM VARIOUS AUTHORITIES PER DEGREE PER HOUR.

MATERIAL.	AUTHORITY.	Calories per sq. metre one metre thick. Degree C.	B. T. U. per sq. foot, one foot thick, Degree F.
Underground Strata	Forbes and Wm. Thomson	1.8	2.19
Limestone	" " " "	1.82	2.21
Sandstone of Croigleith Quarry	" " " "	3.84	5.67
Sand of experimental garden	" " " "	0.94	1.15
Trap rock of Colton Hill	" " " "	1.50	1.75
Porphyritic trachyte	Arvton and Perry	2.12	2.57
Water	J. P. Bottomley	0.72	0.88
*Copper	Latest determinations	32.6	38.3
*Iron	" "	57.5	69.
*Zinc	" "	56.0	68.
*Lead	" "	28.0	33.8
Air, O; N, & CO	Clausius & Maxwell	0.0177	0.0215
Carbon dioxide, CO^2	" "	0.0137	0.0163
Hydrogen, H	" "	0.0125	0.0151

* The values for good conductors are much larger than obtained by Péclet. Thus he found the coefficients of conductivity for the above as given below:

Copper	Péclet	69	
Iron	"	28	
Zinc	"	28	
Lead	"	14	

Péclet deduced formulas for determining the heat conductivity when the temperature of the air in contact with the surfaces was known. For this case it is necessary to take into account the loss of heat by radiation (K) and by convection (K′) which passes off from the surface. The results, he states, are at best approximate, because of the ever changing action of the wind, the sun, etc. The results are based on the approximate law of Newton, that the heat transmitted varies directly with increase in temperature instead of on the more correct and complicated laws of heat emission, in order to secure simplicity in the formula.

Denote by M, the total heat transmitted per unit of area.

Denote by C, C′, etc., the coefficient of conductivity of the various materials.

Denote by e, e′, etc., the thickness of the various materials.

Denote by $Q = K + K'$ the loss of radiation and convection.

Denote by t the temperature of the warmer surface of the material.

Denote by t′ the temperature of the cooler surface of the material.

Denote by T the temperature of air on the warmer side.

Denote by T′ the temperature of the air on the cooler side.

We then have the following three fundamental equations, which may be combined so as to determine t and t′:

$$M = \frac{C(t - t')}{e} \qquad M = Q\,(T - t) \qquad M = Q\,(t' - T').$$

By combining these we find

$$t = \frac{T\,(C + Qe) + CT'}{2\,C + Qe}$$

$$t' = \frac{T'\,(C + Qe) + CT}{2\,C + Qe}$$

$$M = \frac{C\,(QT - T')}{2\,C + Qe}.$$

From the last equation it is noted that when Qe is so small with reference to C that it may be neglected, we have

$$M = \tfrac{1}{2}\,(QT - T')$$

which is of practical application to the transmission of heat under certain conditions, as, for instance, through glass.

If the wall is composed of several parts in juxtaposition, but between which there is an abrupt change of temperature, and of which e, e′, e″, etc., is the thickness of each part, and C, C′, C″, etc., the corresponding coefficient of conductivity, it may be shown that

$$M = \frac{Q\,(T - T')}{2 + Q\left(\frac{e}{C''} + \frac{e'}{C'} + \frac{e''}{C''} + \text{etc.}\right)}.$$

If the various parts of the walls are separated by air spaces, so that we have a discontinuous wall, then it is shown that

$$M = \frac{Q\,(T - T')}{2 + Q\left(\frac{e}{C'} + \frac{1}{Q} + \frac{e'}{C'} + \frac{1}{Q} + \frac{e''}{C''} + \text{etc.}\right)}.$$

If each part of the wall is of the same nature and of the same thickness e, and if there are n parts,

$$M = \frac{Q\,(T - T)}{2 + \frac{n\,Q\,e}{C} + n - 1}.$$

The above formulæ apply when the entire surface of a room is not exposed. For this latter case the formulæ are somewhat different and the heat transmission somewhat less, due to a cold layer of air in the room next to each wall. Péclet's formulæ show a decrease in the loss of heat from walls and windows due to this cause. Regarding both of these latter statements, the hypothesis of Péclet is probably in error, as it is founded on experiments of heat transmission from hot bodies inclosed in the still air of a room, which is essentially different from the case of a wall exposed to the outside air.

For the transmission of heat through glass, the equation

$$M = \tfrac{1}{2}\,(T - T')\,Q \text{ applies.}$$

For an area of one square metre and for a difference of one degree centigrade in temperature, the following is the heat transmission:

Height in metres..........	1 metre	2 metres	3 metres	4 metres	5 metres
Heat transmission deg. Centigrade..............	2.65	2.56	2.52	2.496	2.479
	This reduced to English measure and expressed in B. T. U. per degree becomes:				
Height in feet............	3 ft. 3 in.	6 ft. 7 in.	10 ft.	13 ft. 3 in.	16 ft. 3 in.
Heat transmission per sq. ft. per deg. F., B. T. U..	0.98	0.945	0.930	0.92	0.915

For multiple glass the above numbers are to be multiplied by the following numbers:

Double ($\frac{2}{3}$). Triple ($\frac{1}{2}$). Quadruple ($\frac{2}{5}$). In layers $\left(\frac{2}{1 + n}\right)$.

The following values are computed from Péclet's formula, as stated, and reduced to English units by use of the methods and coefficients given. It is copied from my work on Heating and Ventilation, page 56.

AMOUNT OF HEAT IN BRITISH THERMAL UNITS PASSING THROUGH WALLS PER SQUARE FOOT OF AREA PER DEGREE DIFFERENCE OF TEMPERATURE PER HOUR.

Thickness in Inches.	Solid Wall.		Wall with Air Space.
	Brick or Stone value of (K).	Wood (K).	Brick or Stone.
4	0.43	0.12	0.36
8	0.37	0.065	0.30
12	0.32	0.045	0.25
16	0.28	0.033	0.21
18	0.26	0.031	0.19
20	0.25	0.03	0.18
24	0.24	0.029	0.17
28	0.22	.....	0.15
32	0.21	.....	0.13
36	0.20	.....	0.12
40	0.18	.....	0.10

Professor Kinealy states that the following values of the coefficients are adopted by the State of Prussia, K being the heat transmission in B. T. U. per sq. ft., per degree difference of temperature:

Brick Work.		Sandstone.		Windows.	Value K.
Thickness, Inches.	Value K.	Thickness, Inches.	Value K.		
4.72	0.402	11.8	0.451	Single window.	1.03
9.85	0.348	15.7	0.390	Double window.	0.472
15.00	0.266	19.7	0.348	Single skylight.	1.09
(*18)	(0.25)		0.318	Double skylight.	0.492
20.1	0.226	23.8			
(*23)		(25)			
25.2	0.184	27.6	0.287	Doors.	0.410
30.3	0.164	31.5	0.266	Plaster 1.6 to 2.6 inches thick.	0.615
35.4	0.133	35.4	0.246	Plaster 2.6 to 3.2 inches thick.	0.492
40.5	0.123	39.4	0.226		
45.6	0.113				

* Interpolated.

From these tables it is seen that a fair average value of K or the heat transmitted in B. T. U. per square foot per hour, is for glass, unity, and for ordinary masonry walls one-fourth as much; wood walls of the character indicated by Péclet are not practically in use. A house of modern wood construction with tarred paper under the siding is in practice about equal to a brick or masonry house.

It is impossible in practice to consider all the variations that affect the heat transmission, and it seems better to consider an average case and then increase or diminish the results as the

conditions may require. This, indeed, is probably as accurate as to assume conditions necessary for the detailed calculation of the heat transmission through each part of a building as described in the detailed instructions, as given by Péclet. Indeed, considering the uncertainty in the values themselves, it is somewhat difficult to perceive the advantage of an accurate computation applying such coefficients to each and every part of a building for the reason that the results, no matter how carefully computed, cannot be more accurate than the coefficients themselves. The application of these coefficients to an average or general case permits a rational computation of the heat which must be supplied by the heating surfaces, said result being subject to correction to suit the various conditions and to account for variation from the mean case.

As shown by the experiments described, each square foot can be considered without sensible error as transmitting per degree Fahrenheit per hour as follows:

Glass, 1 B. T. U.; exposed wall of building, ¼ B. T. U.

If we denote the area of glass in square feet by G and of exposed wall in square feet by W, the average heat loss would be for one degree difference of temperature:

$$M = G + \tfrac{1}{4} W.$$

In my computations I assume the outside doors as equal to the same amount of glass surface, also roof walls under an attic not heated as one-half exposed surface.

The total heat to be supplied to a room must also be sufficient to warm any air that enters. This adventitious air will generally be sufficient to change the cubic contents once an hour at least, and when the doors are opened or closed often it may change the air two or three times. For the usual temperature of a room one B. T. U. will warm 55 cubic feet one degree.

Hence, the total heat to be supplied per degree difference of temperature, calling V the cubic contents of the room, n the number of times the air is changed per hour, would be as follows:

$$M = G + \tfrac{1}{4} W + \frac{nV}{55}.$$

A good steam radiator will give off under usual conditions 280 B. T. U. per hour. For this latitude we need to supply heating surface sufficient to warm the building to 70 degrees Fahrenheit in zero weather.

For these conditions the radiation for steam heating will be

$$R = \frac{70}{280}\left(G + \tfrac{1}{4} W + \frac{nV}{55}\right) = \tfrac{1}{4}\left(G + \tfrac{1}{4} W + \frac{nV}{55}\right).$$

The above formula gives the radiation for the least exposed rooms, as the effect of the wind has not been considered in the derivation; hence the results should be increased 10 to 20 per cent. for the most exposed rooms or other adverse conditions.

The results are changed but little by substituting 50 for 55 in the last formula, in which case

$$R = \tfrac{1}{4}\left(G + \tfrac{1}{4} W + \frac{nV}{50}\right) = \tfrac{1}{4}\,(G + \tfrac{1}{4} W + 0.02\, nV)$$

the latter result being easily computed.

DISCUSSION.

Mr. Cary: In looking over the application of the coefficients, we find there is considerable disagreement among the authorities. The paper is a most important production. I have heard from time to time of the coefficients by Péclet being discredited, and to have them confirmed in this way is a matter I look upon with a great deal of interest.

Mr. Barron: It is unfortunate that this paper has come forward at this time, because gentlemen competent to discuss it are not here. I do not know anything about it. I want to know how to begin to calculate the conductivity through a building. American engineers differ from the Continental engineers and from the early engineers, as Tredgold, Buchanan, Hood or Dr. Reed. Those men in the beginning of heating wanted to know how much heat was transmitted through the wall. It is a matter of courtesy to Mr. Reck to discuss it. If Professor Carpenter were here I would ask him to discuss it. I know Mr. Hauss has a table of coefficients. We want, as a matter of courtesy, to show the engineers abroad that we are interested in their works.

Mr. Cary: I do not know whether Mr. Barron has read the paper, but the coefficients which are given here are the results of many tests which have been made by people who are well capable of making them and it is to determine, as stated in the table on the fifth page of the paper, how many heat units in pounds will, in an hour, pass through a layer of some material, one foot square in area, one inch thick for each degree of difference of temperature. It is very simple. The paper shows the result of Péclet's experiments, where he actually took the different materials which we named here and by test found the number of heat units which were transmitted through the several materials.

XCVIII.

THE PERFORMANCE OF CENTRIFUGAL FANS UNDER ACTUAL WORKING CONDITIONS.

BY H. EISERT.

(Member of the Society.)

The literature on fans and related subjects has been greatly enriched in recent years, and the additions furnish, in a general way, quite interesting reading. Unfortunately most of these publications are mere reports of experiments made with specially constructed fans under specially created conditions without a proper and competent analysis of the results. Even in the presented form and manner of treating the subject, many of these publications, notes, and statements would be more beneficial to the profession if the offered conclusions were more logically developed within the limits set by the conditions of the experiment and less arbitrarily extended beyond that province.

It is perhaps timely to emphasize the great difference between an experiment as it is usually made with a special fan in a laboratory, and the test of a commercial fan under actual existing working conditions. No engineer will deny the importance of any experiment that is judiciously conducted by a competent person. On the contrary, there is still a very urgent need for more experiments of that character. With data from such experiments, especially when obtained from different sources to broaden the scope of comparison and analysis, a more satisfactory method can be established upon which the most economical and efficient fan wheels and their housings may be constructed for general as well as for special purposes. Of course, such results in the first place would benefit the fan manufacturer, but a thorough knowledge of these same results would also enable an engineer, who is called upon to design a plant requiring the use of one or more centrifugal fans, to better judge the merits of the various designs of fans now in

the market, before making his selection. The importance of such knowledge is still more emphasized by the fact that no two fans of different makes are proportioned alike for the same nominal size. This variation in the proportions of commercial fans undoubtedly shows that each fan manufacturing concern made its own experiments, the results of which culminated in the adoption of the particular proportion of the fan wheels and fan housings of its make. Since the results of these individual experiments, as a rule, are not accessible for technical and scientific comparison and analysis, it is only in the interest represented by the engineering profession in general that disinterested and representative parties should make tests of commercial fans of all makes as to their possible performance under actual working conditions. Comparative tests of this character would not only show the relative merits of the different fan constructions, but also establish true and fair data that would prove of value to the engineer, when called upon to determine the expected or required performance of a commercial fan under any presented conditions.

The very fact that investigations with that end in view have been neglected, shows a lack of progressive engineering spirit, as well as a lack of the proper knowledge of the real needs of the profession for such information on this subject, such as will enable the practising engineer to judge and decide for himself and thus prevent him from being thrown on the mercy of some fan manufacturing concern.

This generally acknowledged state of affairs makes it so much more deplorable that certain formulae have been introduced and recommended for practical application that either were derived from experiments limited to one specially constructed fan under such artificially created conditions as never can be accepted to represent actually existing working conditions, or formed by conclusions not consistent with the results of the experiments from which they are supposed to be derived.

One formula of the former class is:

$$v = 80\sqrt{p} \quad \ldots\ldots\ldots\ldots \quad 1,$$

as offered by Prof. R. C. Carpenter in "Investigations of a Blowing Fan" (Proc. A. S. H. & V. E. 99, page 233). This

formula was derived from experiments made by several engineering graduates under the direction of Professor Carpenter with a specially designed fan, and which, to all appearance and intention, "were principally devoted to determine the effect of the casing, and the variation of pressures produced in different portions of the casing, etc." While the experimentators deserve full credit for the favorable result obtained within that province, these results as such, however, do not warrant the conclusion presented in the proposed formula for application in an entire different province of interest and conditions. That there has been a certain amount of hesitancy and uncertain feeling in deciding upon its final form, is evidenced by the manner of its introduction. On one side the promise is made that it "would give very closely the pressure produced under ordinary working conditions," and at the other side the amendments that it "would be extremely approximate and depend to a great extent on the resistance to the flow of air."

It takes but little consideration to arrive at the conclusion that a formula based on such generalities as "ordinary working conditions," and depending on such an uncertainty as the "resistance of the flow of air," cannot inspire confidence. First, what constitute "ordinary working conditions"? Every engineer knows only too well from practical experience how much the "ordinary working conditions" of plants requiring the use of fans vary, and it will be readily conceded that the assumption of a mean representing the "ordinary working conditions" of a fan is rather hazardous. Second, are the proportions of the fan, and with that its capacity and efficiency, included in the "ordinary working conditions"? In that case the fan manufacturers are entitled to a very just protest. Third, the failure to promptly correct the erroneous conception brought forth in the discussion of the paper, that p in the proposed formula (1) represents the produced pressure in ounces per square inch, whereas the development preceding the final statement of the formula unmistakably implies that it must be interpreted to represent the pressure expressed in inches of a water gauge, casts additional doubt upon the real meaning of the formula. The most serious feature of the formula, however, is its identical form with that given in Kent's "Pocketbook for Mechanical Engineers," on page 513, wherein p

represents the maximum pressure, in ounces per square inch, that possibly could be produced by a fan. This feature accounts perhaps for the erroneous conception of the proposed formula as experienced in the discussion thereof. (See page 233, Proc. A. S. H. & V. E. 99).

The most representative formula of the other class is the above referred to formula:

$$v = 80\sqrt{p} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 2,$$

given in Kent's "Pocketbook, etc." (page 513), which in that form must be very limited in its practical value, as it represents only a very approximate conversion of the still more approximate formula:

$$H = 0.617\frac{v^2}{g} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 3,$$

so erroneously supposed to represent the results of Buckle's experiments.

The error in the formula at once becomes apparent when comparing it with Buckle's own conclusions as they are given in Kent's "Pocketbook, etc.," on pages 511 and 512, and which are very clear on the subject.

The sum and substance of these conclusions, as far as relating to the possibly produced pressure in a fan, can be stated, and perhaps in a more comprehensible form, as follows:

The experiments were made with two fans of the same diameter having blades of different lengths, namely, 14 inches in one case and 8 inches in the other. The peripheral velocity of both fans was the same, viz.: 236.8 feet per second. Though the diameter of the fan wheel over the tips of the blades is not directly given, it is indirectly so by the statement (on page 512): "In the 14-inch blade the tip has a velocity 2.6 times greater than the heel," from which follows that the diameter

$$d = 2 \times 2.6\left(\frac{d}{2} - 14\right) = \frac{72.8}{1.6} = 45.5 \text{ inches},$$

and the diameter at the heel of the blades $45.5 - 28 = 17.5$, the same as the diameter of the fan inlet as stated (on page 511).

Thus the diameter at the heels of the blades of the other fan wheel is

$$45.5 - 16 = 29.5 \text{ inches},$$

which again corresponds to the statement (on page 511) that "the velocity of the heel of the 14-inch blade is in the ratio of 1 to 1.67 to the velocity of the heel of the 8-inch blade," viz.:

$$17.5 - 1.67 = 29.225,$$

as near as can be expected from the crude statement.

It is now further stated (on page 511) that "with a vane 14 inches long, the tips of which revolve at the rate of 236.8 feet per second, air is condensed to 9.4 ounces per square inch above the pressure of the atmosphere, with a power of 9.6 H.-P.; but a vane 8 inches long, the diameter at the tips being the same, and having, therefore, the same velocity, condenses air to 6 ounces per square inch only, and takes 12 H.-P.

A comparative analysis of this statement reveals the fact that the ratio of the produced pressures

$$\frac{9.4}{6} = 1.57 \quad \ldots \ldots \ldots \ldots \ldots \ldots \quad 4,$$

is as near equal to the inverse ratio of the corresponding proportions of the fan blades in the form

$$\frac{1 - \left(\frac{8.75}{22.75}\right)^2}{1 - \left(\frac{14.75}{22.75}\right)^2} = \frac{0.852}{0.582} = 1.51 \quad \ldots \ldots \ldots \quad 5,$$

as can be expected under the given conditions, and confirms in cold figures the following conclusions by Buckle: ". . . that the length of the vane demands as great a consideration as the proper diameter of the inlet opening."

"In its passage along the vane it (the air) becomes compressed in proportion to its centrifugal force.

The greater the length of the vane, the greater will be the difference of the centrifugal force between the heel and the tip of the blade; consequently the greater the density of the air" —and with that its static pressure.

Further, it is too well known to necessitate a reference to any special experiment or source of information, that the pres-

sure produced by a fan varies also with the form of the fan blades, being least for fan wheels with the blades bent backwards from the direction of revolution, and the most for wheels with the blades bent forward, the value for radial blades being intermediate.

These conclusions and well-known facts now form a very convincing proof that a formula for the determination of the pressure that possibly can be produced by a fan must take not only the proportions, but also the form of the fan blades into account.

Theoretically such a formula has been established in the form

$$H = \frac{\omega}{g}(v_0 r_0 - v_1 r_1) \dots\dots\dots\dots\dots 6,$$

when:

H = the produced pressure expressed as the height of a column of air in feet;
ω = the angular velocity of the fan wheel;
v_0 = the tangential velocity of the air at the tips of the fan blades;
v_1 = the same at the heels of the fan blades;
r_0 = the radius of the fan wheel at the tips;
r_1 = the same at the heels of the fan blades, and
g = 32.16 = the coefficient of acceleration.

The effect of the curvature of a fan blade upon the movement of the air through the fan is clearly illustrated in Figures

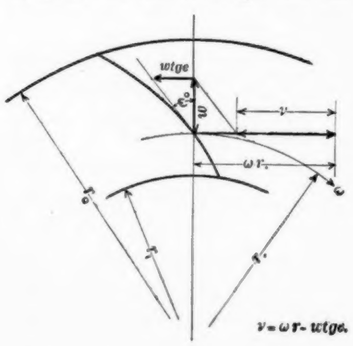


Fig. 1

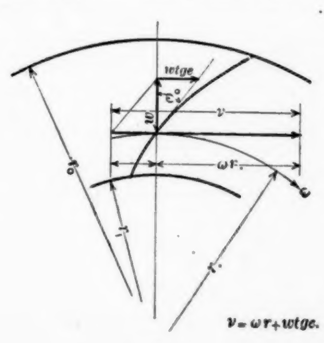


Fig. 2

1 and 2, and the ratio of the tangential velocity of the air to that of the fan blade, at any distance: r from the centre, may therefore be expressed by the general equation:

$$v = \omega r \mp w \, tge \quad \ldots\ldots\ldots\ldots\ldots \quad 7.$$

Though the relative radial velocity of the air through the fan wheel can be assumed to be constant, as all fan wheels decrease in width from the inlet ring to the outer circumference, as shown by Figure 3, in the ratio $\frac{b_0}{b_1} = \frac{r_1}{r_0}$, which presupposes, that br = constant for any radius between the values r_1 and r_0, the absolute radial velocity of the air w is, within certain limits,

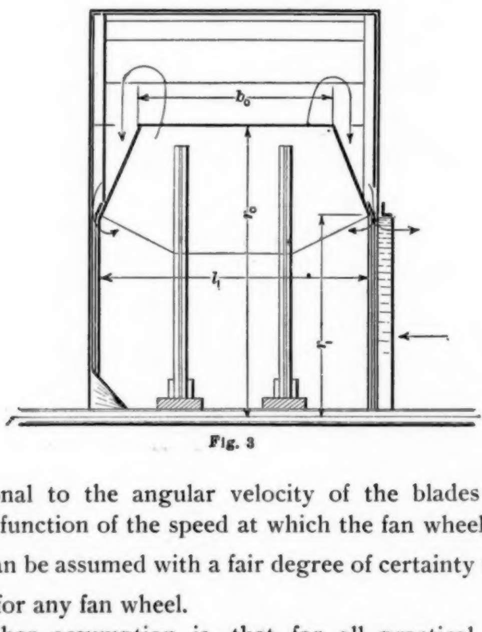


Fig. 3

proportional to the angular velocity of the blades ω, which itself is a function of the speed at which the fan wheel revolves. Thus it can be assumed with a fair degree of certainty that $\frac{w}{\omega}$ = constant for any fan wheel.

Another assumption is, that for all practical purposes also $\frac{tge}{r}$ = constant.

for the reason that whenever our commercial fan wheels are built with curved fan blades this curvature will conform to the Archimedian spiral or a form very near thereto, except in some specially constructed fans, not generally in use.

The natural consequence of the assumptions is now that the ratio of the tangential velocity of the air to that of the fan blades, at any distance r from the centre, is a constant of a definite value for each individual fan wheel and determined by the curvature of the fan blades. This ratio may be represented in the following by the coefficient

$$\beta = \begin{Bmatrix} 1 - \frac{w}{\omega}\frac{\text{tge}}{r} & \text{for blades bent backward,} \\ 1 & \text{" radial blades,} \\ 1 + \frac{w}{\omega}\frac{\text{tge}}{r} & \text{" blades bent forward,} \end{Bmatrix} \quad \ldots\ldots 8.$$

The establishment of the coefficient B allows now the transposition of the general formula 6 into

$$H = \beta \frac{u_0^2 - u_1^2}{g} \quad \ldots\ldots\ldots\ldots\ldots 9,$$

when successively substituting the respective values from the following equation:

$\omega r_0 = u_0 =$ the circumferential velocity at the tips, and
$\omega r_1 = u_1 =$ the same at the heels of the fan blades.
$v_0 = \beta u =$ the tangential velocity of the air at the tips, and
$v_1 = \beta u_1 =$ the same at the heels of the fan blades.

Formula 9, however, will be more subservient for a comparative analysis of formulae now in use or recommended for practical use when transposed into the form:

$$H = \beta \left(1 - \frac{r_1^2}{r_0^2}\right) \frac{u^2}{g} \quad \ldots\ldots\ldots\ldots\ldots 10,$$

when $u =$ the circumferential velocity of the fan wheel and r_1 and $r_0 =$ the radii as illustrated in Figure 3.

The theoretical pressure head H, by formula 10, will rarely be produced under "actual working conditions," and never with a closed outlet opening. The principal reason for this failure is undoubtedly in the more or less imperfect proportions of the fan wheel and its housing, especially the latter, which favor the creation of an independent circulation of the air within the fan by the escape of a greater or lesser quantity of air past the sides of the fan wheel, whence partly it will flow out through

the fan inlet and partly re-enter the fan wheel in the manner indicated in Figure 3, by the arrows. This circulation naturally will be intensified by an increased speed of the fan, because of the correspondingly increased difference between the pressure of the air in the fan housing and that prevailing at the fan inlet. An excessive circumferential speed of the fan wheel appears to have an additional unfavorable effect which seems to be due to the friction of the air upon the fan blades, which prevents the air from attaining the necessary radial velocity to clear the tips of the fan blades in the proper time for discharge, and thus causes a certain retardation of the flow of the air through the fan.

It stands to reason that fan wheels with longer blades will be more subject to a failure of this character than wheels with shorter blades. It even appears that the friction of the air upon the fan blades increases with the circumferential velocity, in spite of the correspondingly increased centrifugal force of the air particles resulting therefrom. Though the results of some experiments made by Mr. Henry Snell seem to point that way, further authentic corroboration is needed.

These phenomena, in addition to the unavoidable sudden cut off of the air currents leaving the fan wheel, which are more or less contracted by the inert action of the individual particles of such an elastic substance as air, must be considered as one, if not the principal, cause of the noise made by many fan wheels when running at a circumferential speed of over 100 feet per second; and therefore furnishes an additional reason for maintaining the circumferential velocity of fan wheels for ventilating purposes within that limit, since, according to practical experience, centrifugal fans give the highest delivering efficiency when running at a circumferential speed of between 80 and 100 feet per second.

However, actual experiments have demonstrated that the theoretical pressure head by formula 10 can be nearly produced in a well-propotioned fan housing with a very much contracted outlet opening, but such results have practical value only in so far as they tend to show that the proportions of a fan and its housing are nearing perfection. The grade of this perfection can now, most conveniently, be measured by the ratio of the actually produced maximal pressure to the theoretical pres-

sure head H, by formula 10. By terming this ratio the "efficiency of a fan wheel and its housing as a pressure producer" and representing the same by the coefficient η_p, the final form of a general formula for the determination of the actual maximal pressure, that possibly can be produced by any fan, will then be:

$$H = \eta_p \cdot \beta \cdot \left(1 - \frac{r_1^2}{r_0^2}\right) \frac{u^2}{g} \quad \ldots\ldots\ldots\ldots 10a.$$

In this formula the produced pressure is represented as the height of a column of air in feet, while in practice it is customary to represent such pressures by the equivalent height, h, of a column of water in inches, which to the former bears the relation:

$$\frac{h}{H} = 12 \frac{\text{density of air}}{\text{density of water}} \quad \ldots\ldots\ldots\ldots 11.$$

In this relation and whenever else referred to comparatively, the density of water is generally accepted at the mean temperature 62 degrees Fahrenheit, and represented by the figure 62.355, that is: the weight of one cubic foot of water, while the corresponding density of air must be expressed at the temperature (t° F.) of the air or gases delivered by the fan at 32 degrees Fahrenheit, and at the mean barometric pressure of the atmosphere at sea level which is generally accepted at 29.921 inches of a mercury column. Dry air weighs 0.0807 pounds per cubic foot and expands $\frac{1}{492.2}$ of its volume for every increase of one degree Fahrenheit in temperature. For convenience sake this ratio of expansion is generally represented by the conventional symbol α. Thus one cubic foot of air of 32 degrees Fahrenheit will occupy at the temperature t° Fahrenheit the volume $1 + \alpha(t - 32)$ cubic feet, and weigh $\frac{0.0807}{1 + \alpha(t - 32)}$ pounds per cubic foot. This weight varies further with the barometer pressure of the atmosphere and the absolute pressure of the delivered air at the ratio:

$$\frac{B}{29.921} \cdot \frac{14.696 + 0.036h}{14.696},$$

wherein

B = the actual barometric pressure of the atmosphere;

29.921 = the accepted normal barometric pressure of the atmosphere at sea level;

14.696 = the absolute pressure of the atmosphere at normal barometric pressure expressed in pounds per square foot;

0.036 = weight of one cubic inch of water, and

h = the pressure of air above that of the absolute pressure of the atmosphere, expressed as the height of a column of water at 62 degrees Fahrenheit.

The absolute weight of atmospheric air is further affected by its contents of moisture to such an extent as represented by the modification of the above stated ratio into:

$$\frac{B - \frac{3}{8}E\frac{p}{100}}{29.921} \cdot \frac{14.696 + 0.036h}{14.696}$$

when

E = the elastic force of the vapor in the atmosphere expressed in inches of a mercury column, and

p = the ratio of saturation of the air with moisture expressed in per cent.

Though the actual weight of one cubic foot of air must thus be expressed in the form

$$\frac{0.0807}{1 + \alpha(t - 32)} \cdot \frac{B - \frac{3}{8}E\frac{p}{00}}{29.921} \cdot \frac{14.696 + 0.036h}{14.696} \text{ pounds,}$$

the fact that, under the conditions to be considered in connection with ventilating plant or induced and forced draft attachments to boiler plants the actual weight of the delivered air or gases differs very little from that of dry air at the same temperature, and that the existence of any such difference is more than made up by the notorious flexibility of the coefficients of efficiency, etc., to be introduced in all pertaining calculations, fully justifies the assumption that, for all practical purposes within the above outlined scope, one cubic foot of air weighs

$$\frac{0.0807}{1 + \alpha(t - 32)} \text{ pounds.}$$

This presupposition allows now the expression of the relation 11, in the more convenient form

$$H = \frac{h}{12} \frac{62.355}{0.0807} [1 + \alpha (t - 32)] = 64.39h [1 + \alpha (t - 32) . \quad 11a,$$

or, when it is preferable to express the pressure in ounces (p) per square inch, in the form:

$$H = 111.52p [1 + \alpha (t - 32)] \ldots\ldots\ldots 11b.$$

The ratio $\frac{64.355}{111.52} = 0.5774$, being identical with the weight of one cubic inch of water at 62 degrees Fahrenheit in ounces, establishes further the comparative relations:

$$\left.\begin{array}{l} p = 0.5774h, \text{ and} \\ h = 1.732p \end{array}\right\} \ldots\ldots\ldots\ldots\ldots 11c.$$

After a transformation upon the basis of these considerations and the introduction of the value 32.16 for coefficient of acceleration, g, the formula 10a will be more subservient for practical application in the form:

$$h [1 + \alpha (t - 32)] = \eta_p \cdot \beta \cdot \left(1 - \frac{r_1^2}{r_0^2}\right) \left(\frac{u}{45.505}\right)^2 \ldots 12,$$

or, when the produced pressure is expressed in ounces per square inch, in the form:

$$p [1 + \alpha (t - 32)] = \eta_p \cdot \beta \cdot \left(1 - \frac{r_1^2}{r_0^2}\right) \left(\frac{u}{59.89}\right)^2 \ldots 12a.$$

By transposing formulæ 12 and 12a, into 13 and 13a, respectively:

$$u = \frac{45.505}{\sqrt{\eta_p \cdot \beta \cdot \left(1 - \frac{r_1^2}{r_0^2}\right)}} \sqrt{h [1 + \alpha (t - 32)]} \ldots 13,$$

and

$$u = \frac{59.89}{\sqrt{\eta_p \cdot \beta \cdot \left(1 - \frac{r_1^2}{r_0^2}\right)}} \sqrt{p [1 + \alpha (t - 32)]} \ldots . 13a,$$

and introducing for the circumferential velocity of the fan wheel, u, its equivalent from $u = \frac{d\pi n}{60}$, the number of revolu-

tions n, at which a fan wheel of the diameter d feet must revolve, in order to produce a certain maximal pressure, can now be determined by

$$\left.\begin{aligned} n &= \frac{869.1}{d\sqrt{\eta_p \cdot \beta \cdot \left(1 - \frac{r_i^2}{r_0^2}\right)}}\sqrt{h\,[1 + \alpha(t - 32)]}, \\ \text{or, } n &= \frac{1144.}{d\sqrt{\eta_p \cdot \beta \cdot \left(1 - \frac{r_i^2}{r_0^2}\right)}}\sqrt{p\,[1 + \alpha(t - 32)]} \end{aligned}\right\} \quad \ldots . \; 14.$$

For certain purposes of comparative analysis, however, formulae 12 and 12a, will be more serviceable in the form:

$$\eta_p = \left(\frac{45.505}{u}\right)^2 \frac{1}{\beta\left(1 - \frac{r_i^2}{r_0^2}\right)} h\left(1 + \alpha(t - 32)\right) \ldots 15,$$

$$\text{and } \eta_p = \left(\frac{59.89}{u}\right)^2 \frac{1}{\beta\left(1 - \frac{r_i^2}{r_0^2}\right)} p\left(1 + \alpha(t - 32)\right) \ldots 15a,$$

Testing Buckle's results by the formula 15a, it will be found that in the case of the 14-inch vanes, when a pressure of 9.4 ounces per square inch was obtained, the efficiency of the fan as a pressure producer amounts to:

$$\eta_p = \left(\frac{59.89}{236.8}\right)^2 \frac{9.4}{0.852}\left(1 + \alpha(t - 32)\right) = 0.705\left(1 + \alpha(t - 32)\right),$$

while in the case with the 8-inch vanes, when a pressure of only 6 ounces per square inch was obtained at the same speed of the fan, the corresponding efficiency amounts to:

$$\eta_p = \left(\frac{59.89}{236.8}\right)^2 \frac{6}{0.582}\left(1 + \alpha(t - 32)\right) = 0.662\left(1 + \alpha(t - 32)\right),$$

showing a slight advantage of the fan with longer blades over that with the shorter ones. If this seeming contradiction of former conclusions cannot be explained by certain structural conditions not accounted for in the records of the tests, it is only one more reason for more exhaustive tests of fans.

By comparing the formula $v = 52.7\sqrt{p}$, as given in the "Investigations of a Blowing Fan" (Proceedings A. S. H. & V. E. 99, page 232), for p expressed in inches of the W. G. reading

and v the circumferential velocity of the fan, from the experiments of Haines and Hobart, with formula 13, it would necessarily be:

$$52.7 = 45.505 \sqrt{\frac{1 + \alpha(t - 32)}{\eta_p \beta \left(1 - \frac{r_1^2}{r_0^2}\right)}},$$

and indicate, for radial blades of the proportion $r_0 = 24''$ and $r_1 = 12''$, an efficiency of the fan as a pressure producer as high as:

$$\eta_p = \left(\frac{45.505}{52.7}\right)^2 \frac{1 + \alpha(t - 32)}{1 + 0.75} = 0.9495\,[1 - \alpha(t - 32)],$$

which is extremely doubtful for a fan working with a closed outlet as in the reported case.

By substituting now for η_p its probable value as established by the data from Buckle's experiments, namely: $\eta_p = 0.7\,[1 + \alpha(t - 32)]$, for the conditions under which the Haines and Hobart experiments were made, it becomes apparent that the offered formula $v = 52.7\sqrt{p}$ is in error and should read:

$$v = \frac{45.52}{\sqrt{0.7 \times 0.75}} \sqrt{h} = 63.5\sqrt{h}.$$

Since both formulae represent the same circumferential velocity v, which implies that

$$63.5\sqrt{h} = 52.7\sqrt{p},$$

it follows that

$$p = \left(\frac{63.5}{52.7}\right)^2 h = 1.45h.$$

This discrepancy clearly shows that the manometer readings in the cited experiments were taken with an open U tube, which recorded the dynamic force of the rapidly moving air within the fan housing and not the actually produced static pressure therein.

It is this error in taking the manometer readings that makes it appear that seemingly produced pressure is 45 per cent. in excess of the maximal static pressure the fan could possibly

produce under the given conditions. The inference is now that any conclusions based on data not entirely eliminating the dynamic force of the moving air must be misleading in the determination of the true performance of fans.

On the other hand, a comparison of the formula $v = 80\sqrt{p}$, as given in Kent's "Pocketbook" on page 513, with formula 13a at once shows that the validity of that formula is limited to such combinations of conditions as will comply with the requirement:

$$59.89 \sqrt{\frac{1 + \alpha (t - 32)}{\eta_p \beta \left(1 - \frac{r_1^2}{r_0^2}\right)}} = 80,$$

and therefore needs no further comment.

Thus far reference has been made only to such data as relate exclusively to the property and relative merits of a fan as a pressure producer, which were obtained by derivation from the laws of Physics and corroborated by experiments.

These data, however, do not allow any definite and reliable conclusions as to the probable performance of any fan under "actual working conditions," without taking a further property of the fan, its capacity to move air or gas, into consideration. The determination of this property of fans has been the real object of the many tests of commercial fans though in some instances it may appear as if the determination of the produced pressure was the more important object in view. When now considering that all these tests were made with fans delivering air at "free discharge," that is: free from and into the atmosphere, it should need no further assertion, that whatever pressure was produced by a fan under such condition, was at once utilized in imparting to the air that velocity at which it passed the fan outlet. The mistaking of the pressure, thus produced, as available to do additional work in the form of overcoming resistance in a series of conduits or otherwise must therefore be justly blamed for so many fans failing in their expected performance under actual working conditions and not the fan, the necessary size of which has not been properly ascertained.

It is not only to prevent such disappointments on the part of the fan users, but also to a considerable extent in justice to the

fan manufacturers, that more clearness should reign in this matter.

It has now repeatedly been demonstrated by actual tests, of which may be mentioned those by Mr. Henry I. Snell, given in Kent's "Pocketbook" on page 516, and which are borne out by the guaranteed statements of the fan manufacturers, that the pressure produced by a commercial fan at its outlet when delivering the air *at free* discharge, that is, free from and into the atmosphere, is identical with the theoretical velocity head of the delivered air, and is clearly defined by the old, but still valid, formula:

$$H = \frac{v^2}{2g} \dots\dots\dots\dots\dots\dots 16,$$

when v = the velocity of the air at the fan outlet in feet per second, or its equivalents:

$$h\,[1 + \alpha\,(t - 32)] = 0.0002415v^2 = \left(\frac{v}{64.355}\right)^2 \dots 17;$$

respectively:

$$p\,[1 + \alpha\,(t - 32)] = 0.0001394v^2 = \left(\frac{v}{84.696}\right)^2 \dots 17a.$$

The formula 16 accounts now for the increase of the pressure produced by a fan, running at a constant speed, when the fan outlet area is reduced, and that because of the resulting increased velocity of the delivered air. This assertion is fully borne out by many experiments, some of which are given in Kent's "Pocketbook" on page 515, and to a certain extent corroborated by the results from the experiments made by Haines & Hobart under the direction of Professor Carpenter, as plotted on plate 7, page 225, and on plate 14, page 234, in "Investigations of a Blowing Fan" (Proc.A.S.H. & V.E. 99), but only when the manometer pressure curves, on both plates referred to, are correctly traced, since the true curves indicated by the dots, which undoubtedly represent the actual results, follow more the character of the pressure curve of an indictor diagram, as it was to be expected.

The maximum of pressure, that can be possibly produced

by a fan at its outlet, will be obtained when the fan outlet is reduced to such an area as will allow the air, at free discharge, to pass at a velocity corresponding to the actual maximum pressure head that can possibly be produced by the fan wheel. This area is now exactly what commonly is termed the "blast area" of the fan wheel, or the "area within the capacity of the fan." Its actual value can readily be ascertained by combining formulae 10a and 16, which under the stated condition represent identical quantities. The equation thus formed, viz.:

$$\frac{v^2}{2g} = \frac{u^2}{g} \eta_p \cdot \beta \cdot \left(1 - \frac{r_1^2}{r_0^2}\right),$$

establishes the relation

$$v = u \sqrt{2\eta_p \cdot \beta \cdot \left(1 - \frac{r_1^2}{r_0^2}\right)} \ldots\ldots\ldots\ldots 18,$$

which, with the circumferential velocity of the fan wheel feet in diameter at n revolutions per minute represented by $u = \frac{d\pi n}{60}$, and the velocity at which the volume $Q_a = q_a n$, in cubic feet per minute, will pass at free discharge the fan outlet, having an effective area of a square inches, represented by:

$$v = \frac{60 \cdot Q_a}{25 \cdot a} = 2.4 \frac{Q_a}{a} = 2.4 \frac{q_a n}{a},$$

assumes the form:

$$\frac{2.4 q_a}{a} = \frac{d\pi}{60} \sqrt{2\eta_p \cdot \beta \cdot \left(1 - \frac{r^2}{r_0^2}\right)} \ldots\ldots 18a,$$

wherein q_a represents the delivering capacity of the fan wheel in cubic feet per revolution under the presented conditions. The corresponding effective area *a* of the fan outlet, that is, the so termed blast area of the fan wheel, or the elsewhere referred to "area within the capacity of the fan wheel," is now determinable by the following transpositions of formula 18a, viz.:

$$a = \frac{q_a}{d\pi} \cdot \frac{144}{\sqrt{2\eta_p \cdot \beta \cdot \left(1 - \frac{r^2}{r_0^2}\right)}} \ldots\ldots\ldots 19,$$

when expressed in square inches, and

$$A = \frac{q_a}{d\pi} \cdot \frac{1}{\sqrt{2\eta_p \cdot \beta \cdot \left(1 - \frac{r_1^2}{r_0^2}\right)}} \quad \ldots\ldots\ldots \quad 19a,$$

when expressed in square feet.

If now the area A, from formula 19a, be represented by the area of a rectangle in the form:

$$A = b_0 x \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 19b,$$

wherein b_0 = the width of the fan wheel at its periphery (see Fig. 3), a combination of formula 19a and 19b produces the equation:

$$b_0 x = \frac{q_a}{d\pi} \cdot \frac{1}{\sqrt{2\eta_p \cdot \beta \cdot \left(1 - \frac{r^2}{r_0^2}\right)}},$$

from which follows that

$$x\sqrt{2\eta_p \cdot \beta \cdot \left(1 - \frac{r_1^2}{r_0^2}\right)} = \frac{q_a}{b_0 \cdot d \cdot \pi} = \rho \quad \ldots\ldots \quad 20.$$

The value ρ, from formula 20, represents as such the radial velocity in feet per second, at which the volume q_a passes the peripheral area $(b_0 d\pi)$ of the fan wheel.

The assumption, that the air delivery of a fan at free discharge, by $Q_a = q_a \cdot n$, is in direct proportion to the number of revolutions, necessitates now, by reason of formula 20, the further assumption, that the actual radial velocity of the air, w, at any number of revolutions n, being also in direct proportion thereto, can be expressed by $n = \rho \cdot n$.

The fact, that the conditions represented in formula 20, are being considered in actual practice, can be illustrated on a well-known make of fan wheels with radial blades which, from the inlet ring, have a length according to the proportion: $\frac{r_1}{r_0} = \sqrt{\frac{1}{2}}$, and an extended heel as indicated in figure 3, which has the effect of rendering the actual value of $\left(1 - \frac{r_1^2}{r_0^2}\right)$ somewhat greater than $\frac{1}{2}$. If it can be asumed, as it is apparently done

in the cited case, that this extension of the heel amounts to so much as to justify

$$2\eta_p \cdot \beta. \left(1 - \frac{r_1^2}{r_0^2}\right) = 1,$$

then will be

$$A = b_0 x = \frac{q_a}{d\pi} = \rho \cdot b_0 \ldots\ldots\ldots\ldots 21,$$

and consequently

$$q_a = d\pi \cdot b_0 \cdot w \ldots\ldots\ldots\ldots 22.$$

This formula has been used for the determination of the delivering capacity of a fan by taking for granted that the available radial velocity of the air per revolution is approximately:

$$w = \frac{d}{3}.$$

When the validity of this assertion is limited to its proper province, which may be represented by the cited special conditions, it is, to a certain extent, corroborated by the empirical formula:

$$\text{Capacity area} = \frac{D \cdot W}{x} = \text{square inches},$$

as given in "Mechanical Draft" by B. F. Sturtevant Co., on page 205, in which:

D = diameter of fan wheel in inches,
W = width of fan wheel in inches at periphery, and
x = constant dependent upon type of fan and casing, which for general practice is not far from 3.

Beyond that, however, it is not tenable to assume that under all conditions, the radial velocity of the air,

$$\rho = x\sqrt{2\eta_p \cdot \beta \left(1 - \frac{r_1^2}{r_0^2}\right)} = \frac{d}{3} \text{ feet}.$$

per revolution of fan wheel. On the contrary, actual tests have shown conclusively that the delivering capacity q of a

fan varies with the area of the fan outlet, and at the same outlet area changes with the form and proportion of the fan blades; the effect of the latter being clearly shown in equation 20. In addition to this, the value of q varies also with the size of the fan inlet, as distinctly stated in Buckle's conclusions. That the provision of a double inlet has a further favorable effect upon the delivering capacity of a fan, is a too well-known fact as to require a corroboration.

Since so many conditions have to be considered, the relations of which to each other have not sufficiently been investigated to justify reliable conclusions, it is only in the interest of the general practice to depend, for the determination of the actual delivering capacity q, of any fan, solely upon the results of actual tests, and to disregard all so-called practical rules for that purpose. The unreliability of such rules cannot be better illustrated as by the " practical rule for capacity " given on page 235 in the Proc. A. S. H. & V. E. for 1899, and its practical contradiction by the accompanying " tests to vary rules."

A further reduction of the outlet opening, below the area corresponding to the possible maximum pressure that can be possibly produced by the fan wheel, tends only to reduce the delivering capacity of the fan per revolution of the fan wheel, while the pressure remains practically constant until towards the closing of the outlet, when the produced pressure will be considerable lower.

The natural inference of this is, that the efficiency of a fan as pressure producer, varies with its delivering capacity in such a way that the value of η_p attains a minimum when the fan outlet is closed, that is, when no air is delivered, and increases with the delivering capacity of the fan per revolutions. This assertion corresponds with the results obtained by Buckle and apparently confirms the assumption of a comparatively high value for η in formula 21.

It stands to reason that, because of structural imperfections, the maximum value $\eta_p = 1$ will never be obtained with any of our commercial fans.

The ratio of the reduction of the delivering capacity per revolution of the fan wheel for fan outlets below the stated limit of area is so nearly directly proportioned to the reduction of the outlet area, as borne out by the experiment of Henry I.

Snell (Kent's "Pocketbook," page 515), that for all practical purposes, when f = the effective area of the fan outlet in square inches and q = the delivering capacity of the fan in cubic feet per revolution of the fan wheel, the coefficient

$$\varphi = \frac{q}{f} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 23$$

can be assumed to be a constant.

The coefficient φ represents the number of cubic feet of air passage per square inch of the effective outlet area at free discharge, in the time the fan wheel makes one revolution, and can be termed the "delivering efficiency of the fan." The *effective* outlet area depends always on the character of the actual opening F, and can be expressed by

$$f = cF \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 24,$$

when c = coefficient that ranges in value from 0.56 to 0.98 according to the character of the opening.

A different condition exists when the outlet area is increased

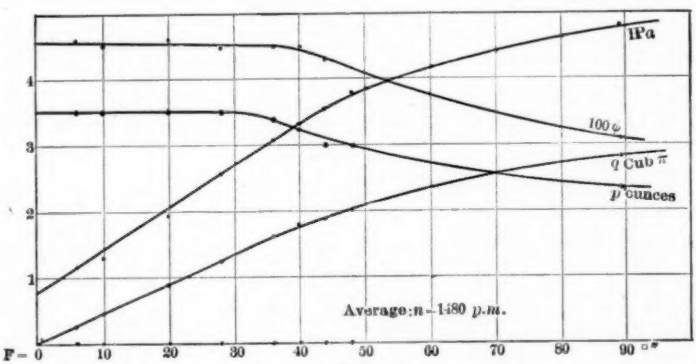


Fig. 4

over the stated limit. Though the delivering capacity q of a fan still increasases with the outlet area f, it is not at the same ratio as for areas *below* that limit. An investigation to that effect of Snell's experiments and tests shows that the value of q increases at a ratio, the character of which is illustrated by the curve in Figure 4.

Following the foregoing consideration, it is but natural to

conclude that the pressure produced by a *commercial fan* at its outlet when delivering the air at *free discharge* depends solely upon its delivering efficiency, and can be expressed by the formula 17 in the form:

$$h\left[1 + \alpha(t - 32)\right] = 0.00139(n\varphi)^2 = \left(\frac{n\varphi}{26.815}\right)^2 \quad . . 25,$$

when substituting for v its equivalent from equation 18a.

In the formula 25, n represents the number of revolutions of the fan wheel per minute, and $\varphi = \frac{q}{f} =$ the delivering efficiency of the fan. It seems hardly necessary to state that the value φ represents a distinct and characteristic property of the fan and as such attains a defined and specific value for each and every individual fan, which for that very reason forms a convenient means for comparing the relative merits of fans of different manufacture at the same commercial size.

The value of φ for any commercial fan can be readily determined from actual test by means of equation 18a in the form:

$$v = 2.4\,n \cdot \varphi \quad . . . . 26,$$

from which follows:

$$\varphi = \frac{v}{2.4 \cdot n} \quad . . . . 27,$$

wherein v the mean velocity in feet per second attained by the air on leaving the fan outlet when the fan wheel revolves at n revolutions per minute.

With its delivering efficiency thus ascertained, it is then but one step further to determine the delivering capacity of any commercial fan by the formula:

$$q = \varphi f \quad . . . . 28,$$

Thus far, the investigations covered the performance of fans only under extreme conditions, that is, as producers of static pressure without delivering any air and as movers of air without producing any static pressure. Neither of these two extreme conditions, however, can be considered as representing what is understood by "actual working conditions," and therefore,

any conclusions therefrom, when applied separately, are absolutely useless as a measure for judging the performance of any fan under given conditions.

The subject of determining the action of a commercial fan under "actual working conditions" has been treated by various writers with more or less success. More satisfactory results, however, will be obtained by the following way of reasoning, which, to a certain extent, is based on Murgue's theory.

In order to do that, it is absolutely necessary to define the actual conditions under which the fan is to work, that is: to determine all possible resistances that may be offered to the flow of air or gases from their intake to the final outlet, either by calculation or comparison of data from actual experience. The sum of these resistances, expressed, as the height, h_r, of water column in inches, represents the resistance against which the fan is to deliver a certain volume of air or gas and with that the "actual working condition."

When stating the required delivery Q of a fan, which, according to the usual practice, is always in cubic feet per minute, the temperature of the delivered air or gas should be given with it.

We assume now the fan to deliver the air into a large room, wherein a static air pressure equivalent to h_r inches of W. G. is to be maintained. This pressure, however, can be maintained only when just as much air flows out of the room as is delivered thereinto by the fan, and is obtained by providing an outlet opening of such effective area as will allow the air to escape at exactly the velocity that corresponds to the maintained pressure as a velocity head. The effective area, a, of the *outlet* opening is thus determined and can be expressed in square inches by the transposition of formula 25, into:

$$a = \frac{Q}{26.815 \sqrt{h_r[1 + \alpha(t - 32)]}} \quad \ldots\ldots\ldots 29.$$

The relation established in formula 29, can also be expressed in the form:

$$Q = 26.815\, a \sqrt{h_r [1 + \alpha(t - 32)]} \quad \ldots\ldots 30.$$

The fact that the fan must deliver exactly the same volume

of air into the room in order to maintain the pressure h_r therein, establishes the additional relation:

$$Q = \frac{fv}{2.4} \quad \ldots\ldots\ldots\ldots\ldots \quad 31,$$

wherein v = the velocity in feet per second at which the volume Q passes the fan outlet of an effective area of f square inches.

It is now apparent that the fan not only must maintain the static pressure h_r in the room, but at the same time produce sufficient additional pressure to cause the delivery of the stipulated volume of air.

As this additional pressure is utilized in imparting the velocity v to the air at the fan outlet, it must be identical with the "velocity head" of the air. This condition, which constitutes that, by formula 17,

$$v = 64.355 \sqrt{(h - h_r)\,[1 + \alpha\,(t - 32)]},$$

when h is the total pressure to be produced by the fan, allows now the expression of formula 31 in the form:

$$Q = 26.815\, f \sqrt{(h - h_r)\,[1 + \alpha\,(t - 32)]} \quad \ldots\ldots \quad 32;$$

and, since formulæ 31 and 32 represent identical qualities, the establishment of the relation:

$$a \sqrt{h_r} = f \sqrt{(h - h_r)},$$

and as a consequent thereof:

$$h = h_r \left(1 + \frac{a^2}{f_2}\right) \quad \ldots\ldots\ldots\ldots\ldots \quad 33.$$

By introducing for a its equivalent from formula 29, this imaginary quality can be eliminated and the formula 33 expressed in the positive form:

$$h = h_r + \left(\frac{Q}{26.815f}\right)^2 \frac{1}{1 + \alpha\,(t - 32)} \quad \ldots\ldots \quad 34.$$

For the purposes of further developments, however, the formula 34 will prove more convenient in the simplified form:

$$h = h_r + h_v \quad \ldots\ldots\ldots\ldots\ldots \quad 35,$$

when:

$$h_v = h - h_r = \left(\frac{Q}{26.815f}\right)^2 \frac{1}{1 + \alpha(t - 32)};$$

that is: the velocity head of the air at the fan outlet.

While the formula 35, in the stated form, offers a convenient means to ascertain the pressure to be produced by a centrifugal fan under given conditions, it is not suitable for determinating the number of revolutions at which a fan of this class must revolve in order to produce the desired result. In a formula for such purpose due consideration must be given to the fact that the performance of any centrifugal fan varies greatly with the conditions under which the performance takes place.

This variation, however, can range only between distinctly defined limits, of which one is represented by the performance of a fan, when its delivery is $Q = 0$, which renders the velocity head $h_v = 0$. In such case the pressure necessarily to be produced by the fan wheel will be $h = h_r$ the resistance head, and the condition becomes analogous to a closed fan outlet.

According to previous conclusions, as illustrated in Figure 4, the required number of revolutions of the fan wheel under such conditions constitutes a minimum, which is determinable by formula 14, viz.:

$$n_{min} = \frac{869.1}{d\sqrt{\eta_p \beta \, 1 - \left(\frac{r_i^2}{r_0^2}\right)}} \sqrt{h[1 + \alpha(t - 32)]} \quad \ldots \quad 36.$$

The other limit is represented by the performance of a fan at free discharge, when the resistance head $h_r = 0$, and the pressure produced by the fan wheel $\overline{h = h_v =}$ the velocity head.

By reason of the same conclusions, the required number of revolutions of the fan wheel under these conditions will constitute a maximum which is determinable by formula 25, in the form:

$$n_{max} = \frac{26.815}{\varphi} \sqrt{h[1 + \alpha(t - 32)]} \quad \ldots\ldots\ldots \quad 37,$$

That the values of n_{min} and n_{max} for these two extreme cases are distinctly different, is further emphasized by their ratio, viz.:

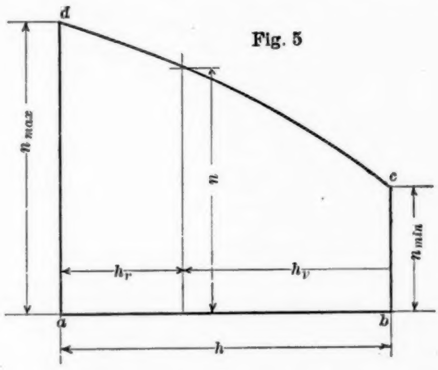
$$\frac{n_{max}}{n_{min}} = \frac{26.815}{\varphi} \frac{d\sqrt{\eta_p \cdot \beta \left(1 - \frac{r^2}{r_0^2}\right)}}{869.1} = 0.0309 \frac{d}{\varphi} \sqrt{\eta_p \beta \left(1 - \frac{r^2}{r_0^2}\right)} \ldots 38,$$

which for most of our commercial fans of the usual standard proportions, is not far from $\frac{7}{3}$.

A graphical illustration of the conditions represented by formulæ 36 and 37, is shown in Figure 5, wherein $ab = h =$ the total pressure produced by the fan; $bc = n_{min} =$ the number of revolutions required to produce the pressure $h = h_r$, when $h_v = o$ (formula 36); and $ad = n_{max} =$ the number of revolutions required to produce the pressure $h = h_v$, when $h_r = o$ (formula 37).

The inference of these conclusions is, that any combination

Fig. 5



of conditions in the form represented by formula 35 will constitute an actual working condition and that the correspondingly required number of revolutions of the fan wheel n, must necessarily be between the limits n_{min} and n_{max}.

A further inference is that for any fan wheel of known proportions the resistance head h_r as well as the velocity head h_v, in the general formula 35, can be expressed as functions of the corresponding number of revolutions required to produce these pressures as such.

Thus since by formula 12 or 14:

$$h_r = \left(\frac{n_1 d}{869.1}\right)^2 \eta_p \beta \left(1 - \frac{r^2}{r_0^2}\right) \frac{1}{1 + \alpha (t - 32)} = n_1^2 R \ldots 39,$$

and, by formula 25:

$$h_v = \left(\frac{n_2 \varphi}{26.865}\right)^2 \frac{1}{1 + \alpha (t - 32)} = n_2^2 r \, \ldots\ldots\ldots \, 40,$$

it stands to reason that the algebraic sum of these two functions as such constitutes a function of the number of revolutions at which the fan wheel must necessarily revolve in order to produce the desired effect under the actual working conditions represented by the general formula 35, in the form:

$$n^2 P = n_1^2 R + n_2^2 r \, \ldots\ldots\ldots\ldots\ldots \, 41.$$

The character of this formula is now such, that, in order to make it possible to comply with the conditions stipulated in formulæ 35 and 36, which require that:

$$n^2 P = n_1^2 R \quad \text{For} \quad n_2^2 r = 0, \text{ and}$$
$$n^2 P = n_2^2 r \quad \text{For} \quad n_1^2 R = 0,$$

the condition:

$$n^2 = n_1^2 + n_2^2 \, \ldots\ldots\ldots\ldots\ldots \, 42,$$

must be complied with.

As now, by formula 14, the number of revolutions required to produce the pressure h_r, as such:

$$n_1 = \frac{869.1}{d} \sqrt{\frac{h_r \left[1 + \alpha (t - 32)\right)}{\eta_p \cdot \beta \left(1 - \frac{r_1^2}{r_0^2}\right)}} \, \ldots\ldots\ldots \, 43,$$

and the number of revolutions required to deliver the volume Q, at free discharge,

$$n_2 = \frac{Q}{q_0} \, \ldots\ldots\ldots\ldots\ldots \, 44,$$

the number of revolutions n, required to produce the pressure h under the given conditions, is finally determinable by the formula:

$$n = \sqrt{\left(\frac{869.1}{\alpha}\right)^2 \frac{h_r \left[1 + \alpha (t - 32)\right]}{\eta_p \beta \left(1 - \frac{r_1^2}{r_0^2}\right)} + \left(\frac{Q}{q_0}\right)^2} \, \ldots \, 45,$$

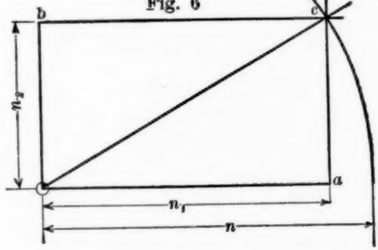
or, in its abbreviated form:

$$n = \sqrt{n_1^2 + n_2^2} \, \ldots\ldots\ldots\ldots\ldots \, 46.$$

The practical solution of this formula is quite simple, though it may not appear so upon a first glance. First, the value for n_1 may be taken direct from a reliable table, giving the number of revolutions required to produce a certain pressure and, when necessary, corrected for the temperature, or a table may be prepared of the values $\frac{869.1}{d} \cdot \frac{1}{\sqrt{\eta_p \beta \left(1 - \frac{r'^2}{r_0^2}\right)}}$ for the various sizes and makes of fans that may come into consideration. In the latter case the corresponding value for the selected size of fan is then to be multiplied with $\sqrt{h_r [1 + \alpha (+32)}$ to obtain the required value of n_1. Second, the value n_2 is obtained directly by dividing the volume of air or gases Q, to be delivered by the delivering capacity of the selected fan at free discharge q_o. With the values of n_1 and n_2 thus ascertained, the necessary number of revolutions n of the selected fan under the given conditions can now be determined by means of the graphical method in the following manner:

Lay off to a suitable scale on the horizontal line (Figure 6),

Fig. 6



the value $n_1 = oa$, and on the vertical line the value $n_2 = ob$, then draw from a line parallel to ob, and from b a line parallel to oa, and the length of the diagonal oc represents direct the value n, which can be read off the vertical or horizontal scale, when describing from the centre o, a circle with oc as the radius, in the manner indicated in diagram, Figure 6.

Formula 46 can now be applied in a comparative analysis of the variation of the number of revolutions necessary to produce a certain pressure h under various combinations of the conditions $h = h_r + h_v$ between the values n_{min} and n_{max}.

For the sake of simplifying matters the ratio:

$$\frac{n_{max}}{n_{min}} = \frac{7}{3}$$

may be used, which allow that the number of revolutions n_1, necessary to produce the pressure head h_r, can be expressed by

$$n_1 = 3a\sqrt{h_r},$$

and likewise the number of revolutions necessary to produce the velocity head h_v by:

$$n_2 = 7a\sqrt{h_v}.$$

Hence, by formula 46:

$$n = \sqrt{(3a\sqrt{h_r})^2 + (7a\sqrt{h_r}^2} = a\sqrt{9h_r + 49h_v}.$$

Assuming now for an instance $h = 4$, and consecutively: $h_r = 0, 1, 2, 3, 4$; $h_v = 4, 3, 2, 1, 0$, then the resulting values of n will be correspondingly: $n = 12.49a, 10.79a, 8.72a, 6a$, which

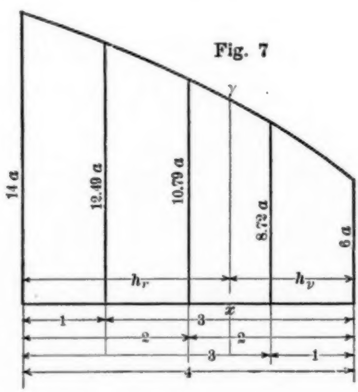


Fig. 7

when plotted out give the curve shown on Figure 7. Thus for any intermediate combination $h_r + h_v = 4$, the corresponding ordinate $x\gamma$ will always represent the necessary number of revolutions n_x under the given conditions.

Such varying performances of a fan under different combinations of conditions must naturally affect the useful work

done. This assertion is fully borne out by the results from various tests and experiments, which prove conclusively the current conception: "the effective or useful work done by a fan is equal to lifting a certain quantity of air per unit of time to a height equivalent to the pressure head produced at the fan outlet," to be true only, when the fan delivers the air at perfectly free discharge.

The popular formula:

$$H.P._a = \frac{1}{\eta_t} \frac{Q \cdot s \cdot v^2}{2g \cdot 33000} \ldots\ldots\ldots\ldots\ldots 47,$$

for the required actual or brake horse-power ($H.P._a$) at the fan shaft, wherein:

Q = the volume of air delivered in cubic feet per minute;
S = the weight of one cubic foot of air;
$\frac{v^2}{2g}$ = the velocity head produced by the fan at its outlet end;
η_t = the mechanical efficiency of the fan, is therefore not applicable to fans running under "actual working conditions."

Equally unsatisfactory are the so-called practical rules intended for that purpose. The purely empirical character of such rules naturally limits their range of applicability to such combinations of conditions as correspond in effect to those from which these rules were derived. The difficulty, if not futility of such a task is clearly illustrated by the "practical rule for power" given on page 237 of the Proc. A.S.H. & V.E. for 1899, and the flagrant failure of the accompanying "tests to verify rule" to accomplish that purpose.

The persistent appearance of power rules in the stated or some other more or less disguised form makes it appear that some of our experimenters and investigators ignore the actual facts, which are not only generally acknowledged in practice, but are also clearly demonstrated by the results from experiments and tests.

The facts are, that the power necessary to drive a fan at a certain number of revolutions varies from a minimum required when the fan is running with a closed fan outlet, that is: when producing the maximum pressure and delivering no air, to a

maximum, required when the fan is delivering the air at free discharge and thereby producing the minimum pressure.

An analysis of the power curves plotted from the results of various tests leads to the conclusion, that for each fan and perhaps make of fans, the minimum horse-power ($H.P._{min}$), which is required to run a fan with a closed outlet at a certain number of revolutions, can be expressed as a proportionate part of the maximum horse-power ($H.P._{max}$), which is required to run the same fan at the same number of revolutions at free discharge, in the manner:

$$H.P._{min} = a\ H.P._{max} \ldots\ldots\ldots\ldots 48,$$

when, by formula 47, after the necessary transposition,

$$H.P._{max} = \frac{1}{\eta_t} \frac{0.219}{1 + \alpha\ (t - 32)} \varphi^2 q_0 \left(\frac{n}{100}\right)^3 \ldots\ldots 49.$$

Judging now from the character of the power curve shown in Figure 4 which has been plotted from the results of Mr. Snell's tests, as given in Kent's " Pocketbook " on page 515, it is very apparent that the variation of the power, required to drive a fan at a certain number of revolutions, between the limits $H.P._{min}$ and $H.P._{max}$ is in a nearly direct proportion with the delivering capacity of the fan, a fact which, to a certain extent is corroborated by the " Investigations of a Blowing Fan " and stated on page 227 of the Proc. A. S. H. & V. E. for 1899, on plate 9.

The fact of this proportionality, once acknowledged, furnishes now a convenient means to determine the actual power required under certain given conditions, that is: " under actual working conditions."

Thus, after ascertaining the number of revolutions, n, at which a certain fan having a delivering capacity of q_o cubic feet at free discharge, must be run in order to deliver Q cubic feet of air at the temperature t°, against a resistance equivalent to the height of a water column h_r inches high, the actual delivering capacity of the selected fan is at once determined by the relation:

$$q = \frac{Q}{n},$$

and with the size, make and efficiency of the selected fan known, the values $H.P._{min}$ and $H.P._{max}$ for n revolutions per minute are at once determinable by the formulæ 48 and 49.

The actually required horse-power $H.P._a$ under the given conditions, can now be determined by the following considera-

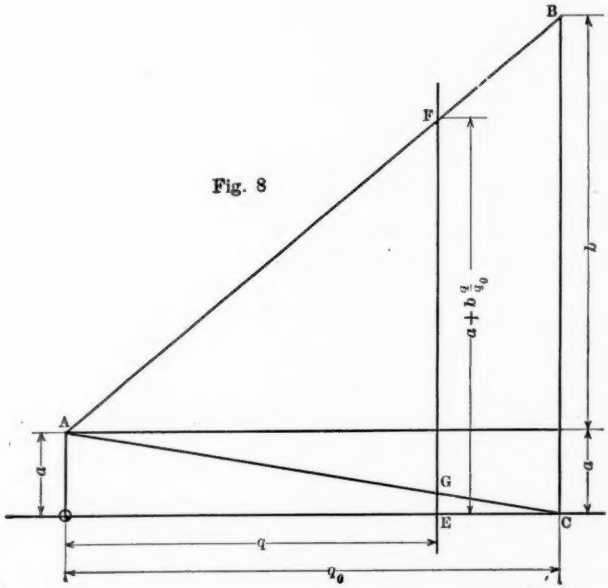


Fig. 8

tion, in which for the sake of better illustrating the performance of the fan, the graphical method will be used.

In the diagram Figure 8 represents: oc = q_o = the delivering capacity of the selected fan at free discharge; $OA = a = \frac{H.P._{m'n}}{H.P._{max}}$, the ratio by formula 47, and

$$BC = 1 = a + b.$$

The values q_o and ω are characteristic of the selected fan and therefore supposedly known.

Accepting now the above stated assertion as practically correct, then a line drawn parallel to OA at a distance OE = q = the actual delivery capacity of the fan, from point O, will be intersected by the line AB so that the distance or length EF

represents direct the relative required horse-power of the fan, as compared with the $H.P._{max}$ required for the same fan when delivering at free discharge.

The actual length of the ordinate EF is now determinable in the following manner. By drawing the line AC it will be

$$EG = a\left(1 - \frac{q}{q_0}\right), \text{ and}$$

$$GF = \frac{q}{q_0},$$

and in consequence thereof:

$$EG + GF = EF = a\left(1 - \frac{q}{q_0}\right) + \frac{q}{q_0} = a + (1 - a)\frac{q}{q_0}.$$

This condition can be illustrated in Figure 8 by drawing the line AD, when $EH = a$ and $HE = (1 - a)\frac{q}{q_0} = b\frac{q}{q_0}$, so that also $EF = a + b\frac{q}{q_0}$.

The performance of the fan as to the required power can be illustrated in Figure 8 in so far as the proportionate part of the power represented by the line GF is consumed in moving the air and that represented by the line EG in overcoming the resistance to the flow of the air.

The formula for determining the actually required horse-power to drive a fan "under actual working conditions" assumes now the final form:

$$H.P._a = \frac{1}{\eta_t} 0.219\, \varphi^2 q_0 \left(\frac{n}{100}\right)^3 \frac{a + b\frac{q}{q_0}}{1 + \alpha(t - 32)} \quad \ldots \quad 50.$$

In this formula the value $\frac{1}{\eta_t}\ 0.219\varphi^2 q_0$ is a constant depending entirely on size, make and efficiency of the selected fan and therefore determinable beforehand, even for the various sizes of fans, and the results put in a tabulated form for ready use, leaving only the variables n, q, and t to be taken care of in the necessary calculation; the values a and $b = (1 - a)$ being also known with the selected fan.

As to the value of the ratio a, few reliable data are obtainable. However, judging from the tests of Mr. Snell, and the plotted

curves on plates 6 and 9, presented with the "Investigations of a Blowing Fan," repeatedly referred to, it appears that for fans with radial blades of the type most commonly used, this value is not far from $\frac{1}{8}$ and as such may be accepted for practical application in connection with fans of that type.

Still less definite data are obtainable in regard to the mechanical efficiences of commercial fans. In the text books these efficiencies are quoted to range from $\eta_t = 0.40$ to $\eta_t = 0.75$. In actual practice when dealing with commercial fans it is extremely doubtful whether higher values than $\eta_t = 0.25$ are ever obtained.

An analysis of the few reliable data that are bearing on this subject shows that the mechanical efficiency of a few, that is: the ratio of the theoretically necessary power to the power actually required to revolve a fan wheel at a certain number of revolutions, varies not only with the construction of the fan wheel and its housing, but also to some extent with the diameter of the fan wheel. It appears even that the mechanical efficiency varies with the circumferential speed of the fan wheel. The favorable effect of an increased diameter can be explained by the fact that the clearance between the fan wheel and its housing is comparatively smaller by a larger fan than by a smaller one, which necessarily reduces the unavoidable back currents from the circumference of the fan wheel to the inlet. This action is further assisted by the increased centrifugal force of the moving air due to an increased speed of the fan wheel. This favorable effect of the increased speed, however, appears to reach a maximum when the fan wheel revolves at a circumferential speed of about 100 feet per second, and thus seems to corroborate the previously stated and explained assertion that fan wheels give the highest efficiency when running at a circumferential speed of between 80 and 100 feet per second.

The mechanical efficiency of commercial fans appears to range from $\eta_t = 0.20$ to $\eta_t = 0.25$, according to size and speed of the fan wheels. For all practical purposes therefore, when the fan wheel is run at the stated most economical speed, it is fully safe to assume an average value for the expression $\frac{0.219}{\eta_t \cdot c^2} = 2.5$ for all commercial fans of the style commonly used for ventilating purposes and in connection with induced and forced

draft attachments of boiler plants. This assertion once acknowledged simplifies the calculation of the necessary power to be delivered to the fan shaft considerably as it renders the formula 50 in the more serviceable form:

$$H.P_a = 2.5 \cdot \frac{q_0^3}{f^2}\left(\frac{n}{100}\right)^3 \frac{a + b\frac{q}{q_0}}{1 + \alpha(t - 32)} \ldots\ldots 51.$$

For specially constructed fans the mechanical efficiency will be higher, and in some rare cases may reach as high a value as $\eta_t = 0.75$. In such an instance formula 50 must be used, when determining the required brake horse-power.

Recent practice has developed the highly commendable custom to attach the motor, whether steam or electric driven, direct to the fan shaft; while the former custom of transmitting the power to the fan shaft by belting is resorted to only in rare cases, prompted by necessity or perhaps preference.

Owing to the comparatively small powers required to drive fans, the motors cannot be expected to develop high efficiencies. It is therefore but natural to allow for steam engines no higher efficiency, that is: the ratio of the horse-power actually delivered at the fan shaft to the indicated horse-power of the engine, than $\eta_e = 0.40$ for small engines and for well constructed and larger engines $\eta_e = 0.50$. For electric motors at full load and efficiency of $\eta_m = 0.70$, may be allowed, which for exceptionally well constructed machines may be increased to

$$\eta_m = 0.75 \text{ or even } \eta_m = 0.80.$$

It remains now only to add a few suggestions in regard to the selection of the proper sized fan required under the given conditions. While it is true that it is desirable to limit the velocity of the air, etc., on leaving the fan outlet as much as possible, since the pressure necessary to create this velocity increases with the square thereof, it is equally true that a reduced velocity of the air when discharging against a resistance, will increase the "back lash," or "back currents" of the air in the fan housing and therewith unfavorably effects the efficiency of the fan. It is therefore advisable to increase for that reason the velocity of the air at the fan outlet in proportion to the resist-

ance to be expected. For all practical purposes it will suffice to assume the mean actual velocity of the discharging air at the fan outlet from 12 to 24 feet per second according to the resistance.

This establishes the relation:

$$f = 2.4 \frac{Q}{v} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 52,$$

when Q = the actual volume of the air, etc., to be delivered per minute, which passes the fan outlet of the effective area square inches at a velocity of v feet per second.

As stated with formula 24, the coefficient of contraction, c, varies with the form of the conduit for the air from the fan outlet, but at the same time it appears that the contraction of the air at the fan outlet rapidly diminishes with the increase of the difference between the velocity head and the actual pressure of the air at the fan outlet. For that reason it seems rasonably safe for all practical purposes, especially where fans of this character are used in connection with ventilating plants and induced draft attachments to boiler plant, to neglect the effect of the contraction of the air at the fan outlet in such cases, so as to justify the use of the actual fan outlet area F instead of the effective area f, as stated in formula 52. Under such assumption that size of a commercial fan may be selected which has an actual outlet area of from $\frac{Q}{10}$ square inches for larger to $\frac{Q}{5}$ square inches for smaller resistances. For ventilating purposes it will rarely occur that a fan with a smaller outlet opening than $\frac{Q}{7\frac{1}{2}}$ square inches will be required.

With the size of the fan thus selected, its delivering capacity q_0 is at once known, which by formula 44, determines the number of revolutions n_2, at which the fan would deliver the stipulated volume Q at free discharge. The character of the fan and the resistance h_r in inches of W. G., by formula 43, determines the number of revolutions n_1, at which the fan would produce the pressure h_r as such. With n_1 and n_2 thus ascertained, the actually required number of revolutions n is then determinable by formula 46.

The number of revolutions n thus ascertained determines now the actual delivering capacity of fan q, by:

$$q = \frac{Q}{n} \quad \dots\dots\dots\dots\dots\dots \quad 53,$$

and by formula 50 respectively 51, the required actual or brake horse-power to be delivered to the fan shaft, leaving only the size of the required motor to be determined under consideration of the driving medium and the expected efficiency of the machine.

The foregoing procedure of calculation can be greatly facilitated by the graphical method, of which an example is presented on the accompanying plate for fans of that class for which it can be assumed that

$$\eta_p \cdot \beta \left(1 - \frac{r_1^2}{r_0^2}\right) = \tfrac{1}{2} \quad \dots\dots\dots\dots \quad 54,$$

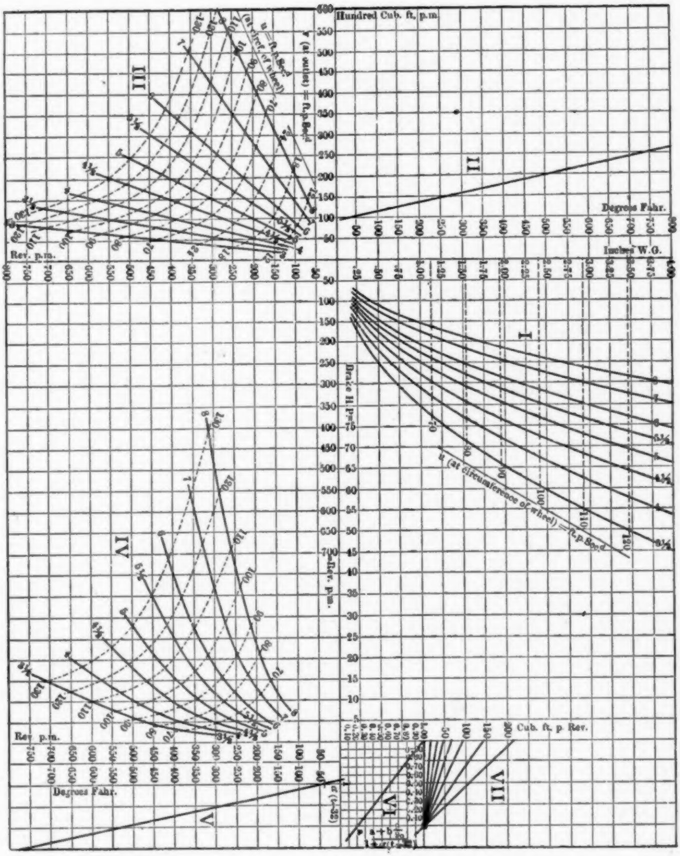
for such fans, and only for such, equation 43, becomes

$$n_1 = \frac{1229}{d} \sqrt{h_r\,[1 + \alpha\,(t - 32)]} \quad \dots\dots\dots \quad 55.$$

This formula (55) represents for each individual fan with a fan wheel of d feet in diameter, the equation of a curve of such character that for any ordinate representing the value $\sqrt{h_r\,[1 + \alpha\,(t - 32)]}$, the corresponding abscissa will represent the value n_1. These curves for fan wheels from $3\frac{1}{2}$ to 8 feet in diameter, of the usual commercial proportions and complying nearly with the stipulated condition represented by formula 54, have been plotted in diagram I, and marked.

The scale on the vertical centre line for the representation of the resistance to the flow of air, etc., expressed in inches of the water gauge, is divided in units equivalent to 0.05 inch of the gauge, while each of the units of the scale on the horizontal centre line represents ten revolutions of the fan wheel per minute.

The temperature scale in diagram II is drawn at the distance from the vertical centre line, and in connection with the inclined line, which intersects the temperature scale at the point corresponding to 32 degrees Fahrenheit, serves to read off


Hundred Cub. ft. p.m.
Degrees Fahr.
Inches W.G.
Brake H.P.
Rev. p.m.
Cub. ft. p. Rev.
u (at circumference of wheel) = ft. p. Sec.
I
II
III
IV
V
VI
VII

directly the value $1 + \alpha(t - 32)$. This value is represented by the distance of the inclined or expansion line from the vertical centre line at the distance equivalent to t degrees from the horizontal centre line.

The arrangement of the temperature and pressure scales is now such, that by a simple procedure the value $h_r[1 + \alpha(t - 32)]$ can be readily constructed in the following manner:

From the point corresponding to a resistance equivalent to h_r inches on the pressure scale, an imaginary line is drawn to the base of the temperature scale on the horizontal centre line. If now the distance from the expansion line to the vertical centre line at the distance t° from the base, which corresponds to the value $1 + \alpha (t - 32)$, is transferred to the horizontal centre line, and from its outer end a line drawn parallel to the before mentioned imaginary line, its intersection with the pressure scale will take place at the point corresponding to the value $h_r[1 + \alpha(t - 32)]$. A horizontal line drawn from this point will intersect any of the pressure curves of the fan wheels at such a distance from the vertical centre line, which, when read off the scale on the horizontal centre line, will represent direct that number of revolutions n_1, at which the corresponding fan wheel must revolve in order to produce the pressure h_r as such without delivering any air or gases.

On the other hand, the formula 43, viz.: $n_2 = \frac{Q}{q_0}$, represents the equation of a straight line, wherein q_0, as the delivering capacity of a fan at free discharge, is supposedly known for each individual fan. The capacity lines for the various fan wheels from $3\frac{1}{2}$ to 8 feet in diameter can thus be readily constructed, as illustrated in diagram III by the radial lines so marked.

These lines, which can be used with sufficient accuracy for most of the commercial fans of the class in general use for ventilating purpose and in connection with induced and forced draft attachments to boiler plants, are drawn so that for each abscissa representing the volume Q to be delivered in one minute, as read off on the volume scale on the horizontal centre line (each unit = 1,000 cubic feet per minute, but marked in ten hundreds) the corresponding ordinate, as read off on the vertical revolution scale (each unit = 10 revolutions per minute)

represents direct the number of revolutions n_2, at which the corresponding fan will deliver the stipulated volume Q at free discharge.

The curves marked 12, 18 and 24 intersect the capacity lines of the various fans at such points, where the corresponding ordinate represents that number of revolutions at which the stipulated volume Q will pass the outlet of the fan represented by its capacity line, at the velocity in feet per second marked on the curves. These curves are mainly intended for a guide in selecting the proper sized fan.

The additional curves marked 70 to 130 intersect the capacity lines at such points where the ordinate represents that number of revolutions of the fan wheel represented by its capacity line, at which the circumferential velocity of the fan wheel will be as marked on the curves in feet per second. These curves are to serve as a check for the resulting number of revolutions n, which preferably should correspond to a circumferential speed within the most economical limits, that is, between 80 to 100 feet per second.

With the values n_1 and n_2 thus established on their scales, the resulting number of revolutions n, required under the given conditions, is now readily obtained by the method explained in connection with Figure 6, its value read off the vertical scale of diagram III and checked by the speed curves as previously explained.

Moreover, that the graphical method can also be advantageously used in calculating the actual or brake horse-power required at the fan shaft under the given conditions, is illustrated in diagrams IV, V, VI, and VII. The plotted curves in diagram IV for fan wheels from 3½ to 8 feet in diameter as marked, are of such character that for any ordinate representing the number of revolutions n, as determined by formula 46 or the diagrams I, II, and III, and read off the scale on the vertical centre line of diagram IV (each unit = 10 revolutions per minute) corresponds to an abscissa representing the value $H.P._{max} = \frac{0.219}{\eta_t \cdot c^2} \frac{q_0^3}{F^2} \left(\frac{n}{100}\right)^3$, as read off the scale on the horizontal centre line (each unit = one $H.P._{max}$).

The horse-power thus determined is the maximum horse-power that would be required to run the fan at the previously

ascertained number of revolutions n, if delivering air of 32 degrees Fahrenheit at free discharge. The obtained result must therefore be corrected by multiplication with the coefficient $\left(\frac{a + b \cdot \frac{q}{q_0}}{1 + \alpha(t-32)}\right)$, which represents the actual conditions under which the delivery of the air takes place.

After ascertaining and marking on the horse-power scale of the diagram IV, the value of the required $H.P._{max}$, the next step is to determine the value of the actual delivering capacity q of the fan under the given conditions.

This can be done either by dividing the stipulated air delivery Q in cubic feet per minute by the previously ascertained number of revolutions n, or, if preferable, by the graphical method in the following manner. After drawing a line from the point on the vertical or revolution scale of diagram III corresponding to the required number of revolutions to the point on horizontal or volume scale of diagram III corresponding to the stipulated volume Q cubic feet per minute, a parallel line is drawn from the point marked 100 on the revolution scale. This line intersects the volume scale of diagram III at a point corresponding to the value $q = \frac{Q}{n}$ when each unit of that scale represents 10 cubic feet and its distance from the centre can now directly be transferred to the vertical or capacity scale of diagram VII, as each unit of this scale also represents ten cubic feet. From the points on this scale corresponding to the values q_0, that is: the delivering capacities at free discharge in cubic feet per minute for the fans from 3½ to 8 feet in diameter, radial lines are drawn to point O on the horizontal centre or base of line of diagram VII, which also represents the scale for the ratio $\frac{q}{q_0}$. The value of this ratio is now obtained by drawing a horizontal line from the point on the capacity scale corresponding to the value q, and a vertical line from its intersection with the radial line marked with the diameter of the selected fan wheel. This line which at its point of intersection marked at once on the ratio scale the value $\frac{q}{q_0}$ is continued to intersect the inclined line from point marked a to the point marked 1 on the ratio scales of diagrams VI and VII, which

corresponds to the inclined line drawn from point A to point B in Figure 8. A horizontal line drawn from this point of intersection will now mark on the vertical or ratio scale of diagram VI the value of the ratio $a + b\frac{q}{q_0}$.

This value, however, is further to be corrected for the temperature t° Fahrenheit of the delivered air or gas. To this end the value $1 + \alpha(t - 32)$ is marked on the horizontal scale of diagram V in precisely the same manner as described in connection with diagram II, and connected with the previously ascertained point on the vertical ratio scale corresponding to the value $a + b\frac{q}{q_0}$. A parallel line drawn from point 1 on the horizontal scale of diagram V will mark on the vertical ratio scale the value of the required coefficient of correction, viz.:

$$\frac{a + b\frac{q}{q_0}}{1 + \alpha(t - 32)}.$$

The final step is now to draw a line from the latter point parallel to a line from point 1 on the vertical ratio line of diagram VI to the previously marked point on the H.-P. scale of diagram IV, corresponding to the value of the ascertained maximum horse-power and the point of intersection with the horse-power scale will finally mark the actual or brake horse-power required at the fan shaft under the given conditions.

In conclusion, it may be added, that the given diagrams are not intended to apply to all commercial fans, because of their varying proportions, but for approximate calculations they are sufficiently reliable. For more exact calculations, diagrams should rightly be constructed for each make and type of fans.

The greatest advantage of the foregoing explained graphical method of calculating the fans and their motors is in the perfect control exercised at any stage of the calculation, which enables the designing engineer to make the proper selection of such sizes as will assure the highest efficiency and economy.

XCIX.

TOPICAL DISCUSSIONS AT THE NEW YORK MEETING.

TOPIC NO 1.

"The Tudor System of Steam Heating as Compared with the French System."

Mr. Paul: I do not know who brought the subject up. The discussion, at the last meeting, I believe, was based on the question whether this French system described in a paper read by the French member of this Society, Mr. Debesson, was the former Tudor system. As Mr. Smith has had considerable correspondence on the subject and has Mr. Tudor's statements regarding it, I think he is very much better prepared to bring up this subject than I am. I, therefore, turn over the subject to Mr. Smith.

Mr. Smith: It seems to me, Mr. President, that Mr. Debesson's suggestion is a very good one and that a very excellent way to compare the French and American systems would be to arrange for one of our American engineers to design the heating of a building according to our present methods, letting Mr. Debesson have the same plans and show how he would produce the same results by the French system. I think I should also add that whatever there is of merit in the French system comes originally from the system of our friends, Mr. Paul and Mr. Tudor.

The President: We are waiting now for volunteers to design this system.

Mr. Gormly: I would like to ask Mr. Smith whether he knows it is a fact that the Tudor, and some other systems, use a radiator for steam having a communicating passage across the top and bottom of the sections—whether it is not true that they use that radiator altogether.

Mr. Smith: I do not know that, Mr. Gormly.

Mr. Gormly: I know that some systems of heating do use a radiator of that kind and I have always been afraid they

would run into trouble for that reason. Some years ago, I was talked into using a water pattern of radiator with low-pressure steam. I found after about three years' use the radiators would leak at the bottom connection between the sections of the radiator, caused probably by the fact that the steam would enter the radiator and run across the top connection, heating and expanding that, while the bottom connection was cold. The result of that expansion a number of times was leaks between sections; it occurred invariably with that pattern of radiator. I have been under the impression that, with a number of these systems, of which I think the Tudor system is a sample—in which they use the water pattern of radiator for steam—trouble will come in four or five years. I know the pressure system in three years brings trouble, for I have been in the trouble. The vacuum system will run two or three years longer before showing the leak.

Mr. Barwick: I would ask Mr. Gormly if he could tell me whether they had been push-nipple or screw-nipple radiators.

Mr. Gormly: Screw-nipple.

Mr. Barwick (continuing): I think we should have, with push-nipple radiators, an unequal expansion, but with screw-nipple radiators it is hardly as likely.

Mr. Paul: What pressure is used on these radiators?

Mr. Gormly: From one to five pounds.

Mr. Paul: I can say, in my experience, that we have used quite a number of radiators of the hot-water type and we have never had a case in which a complaint has reached any of my men or myself. The question of the unequal expansion is governed by the place you put your air valve, and, of course, the condition of the steam flowing into the radiator, as Mr. Gormly stated—it has the tendency to be across the top of the radiator. This also governs and determines where you place your air valve. The time of filling the radiator under the conditions is very short, provided the air valve is put in the proper place. I have had no trouble with expansion. If you put an air valve on a hot-water radiator as high as on a steam radiator then you will have some trouble.

Mr. Smith: It might be well for Mr. Paul to state how many inches above the lower openings he would suggest placing the air valve on a hot-water radiator used for steam.

Mr. Paul: My experience with hot-water radiators used for steam leads me to put the air valve a third of the way from the bottom. With a steam radiator it would be a third of the way from the top. Practically what you have to do is to balance the radiator so as to make it fill uniformly.

Mr. Barron: Mr. Chairman, I do not think that we discussed that paper with enough interest to show proper courtesy to Mr. Debesson's work, for the paper read last year was very valuable. (Referring to diagram on blackboard.) With this diagram I would like to give you my impression of the French or Tudor or so-called "vapor system." It has some peculiar and valuable features. I do not know but that it is superior to our system of steam heating as ordinarily practised. This (indicating) represents a small job of 400 square feet; there are no air valves on the radiators. The second feature is the amount of steam admitted; the regulation is by a graduated valve. The next peculiar feature is that areas of pipe can be one-half of the systems in use with us. The saving in cost ought to be half that of heating a house of that character in this country and it gets over the objections of low-pressure steam heating. This is a radiator which is a condenser; there will be nothing but condensation returning to the tank here (indicating). The radiating surface required will be just as in ordinary work, I should judge. It seems to me that it is well worthy of consideration and discussion. This pipe here (indicating) is an air pipe which goes out of this pipe (indicating); all the air in the system is expelled in this pipe (indicating). The water-seal was Mr. Tudor's main idea. As he applied it, it was largely on large work and not for small house-work. The Frenchmen have adopted it for small house-work.

Mr. Kent: How do you explain the reasons for using small risers? Why does it take smaller pipe than any other system?

Mr. Barron: The purpose of our low-pressure pipe is to maintain the balance, so that work will not back up and seal your drips. On this system you don't require it. You allow for a fall of two pounds.

A Member: How can there be any vapor in the condenser?

Mr. Barron: If you take those seals away you can understand that the condenser is necessary. That, now, is the American vapor system. There are two or three concerns in

this country putting them in; I think they use the ordinary sized pipe. I believe they met certain difficulties and that they have overcome them. That is the American vapor system; I understand the French do not use this condensing radiator. They carry this pipe to the tank.

A Member: That return carried to the water level would seal it also.

Mr. Barron: In articles published on heating and ventilating, contributed by Mr. Debesson, his whole system is explained thoroughly. I have not had time to go into it.

Mr. Quay: How do you reduce the size, requiring a certain sized pipe, to carry a certain amount of steam. The radiation requires a certain amount of steam; it has to be carried through those pipes—the velocity will be given by the size of the pipe. I don't see why he can reduce the risers to ⅜-in. why he reduces them so much.

Mr. Barron: In answer to Mr. Kent's question—I admit it is not a sufficient answer, because, of course, you have to consider the velocities of steam through the pipe. I do not claim that is correct. I have exaggerated the size; it is not correct. I would not put in an experimental plant and put in ⅜ risers; I would not risk less than ¾, but if the French can do that they have done something worth knowing.

Mr. Kent: How can they have the air pipe open and leave a vacuum in the system?

Mr. Hauss: There is no vacuum at all. They have on the boiler a regulator that regulates, thus maintaining a fixed pressure of one pound and a half, the regulator being both sensitive and reliable, depending on mercury or some solution with a low boiling point. This brings the fixed pressure to the valve of the radiator. The radiator valve, termed "fractional valve"—or as it is in German, "Prăcisionsventil," is an ordinary angle or globe valve with a double or quick screw, so one turn of the handle opens or closes it. Under the handle is a dial divided into say six parts, hence if you turn the pointer to 1, then one-sixth of the radiator fills with steam; to 2 will fill one-third, and so on to 6, when the whole radiator is filled with steam. In connection with this valve, in the same body they usually have a sort of plug cock or other seat which is set to limit the maximum amount of steam which can be

admitted. The return pipe is open at the top to the atmosphere.

Mr. Kent: How do they provide against the waste of steam?

Mr. Hauss: The idea is not to allow any more steam to enter the radiator than the radiator is capable of condensing. In some cases a Heintz steam trap or other affair is used on the returns that will allow the water and air to pass out but closes when the steam comes in contact with it. The steam will fill the whole radiator, and with the return disconnected only water trickles out. I have seen that.

Mr. Kent: Will that work with the variable temperature and atmospheric conditions in America?

Mr. Hauss: Yes, sir.

Mr. Kent: Does it require a special radiator?

Mr. Hauss: No, it is all done with the proportioning of the piping and valves.

Mr. Franklin: What size pipe do they use for risers?

Mr. Hauss: I have never seen anything under ¾-inch; they may use smaller pipes, but I doubt it. But they do use ⅜-inch return connections on very small radiators.

Mr. Franklin: That would not be for more than one radiator.

Mr. Hauss: Not from more than one radiator. I have a set of tables given me by one of the leading German engineers, and which he uses in his practice, but there is nothing smaller than ⅜-inch, and it should be used only on short connections and small radiators. This table, as also another table I have, showing the method of figuring the size of radiators for various kinds of exposures, are in German and all dimensions in the metric system, so I could not translate them offhand into English measures or English heat units per square foot.

Mr. Carpenter: They always carry a pound and a half of pressure?

Mr. Hauss: That is right. They have that pressure in the system all the time.

A Member: Where is the pound and a half pressure taken?

Mr. Hauss: At the boiler.

A Member: They carry a pound and a half to the radiator valve?

Mr. Hauss: No, sir; there is less at the valve on radiator than at the boiler.

Mr. Bishop: Is the regulating valve automatic?

Mr. Hauss: No, sir; it must be set for each special case as mentioned before.

Mr. Fowler: The vapor system as being used in Philadelphia is a repetition. The ½-inch pipe is the largest in use they have; this graduating valve is just the same way. You can find it; all the members can get full information in regard to the vapor system by sending for pamphlets to the Vapor Heating Co., York, Pa. It seems to me from what I know of that and what I see of the drawings on the board that one is the reproduction of the other.

Mr. Trachsel: I was considering what system you are trying to work out. If it is the German I know nothing about it. If it is the Broomell vapor system I have erected quite a number of these plants which give sufficient satisfaction. I hear some of you asking what size the mains should be. The rising mains would be for 70 square feet, ½-inch steam pipe, ½-inch return pipe. For 72 feet to 100 square feet ¾ steam or vapor (suppose we call that the flow), ¾-inch flow and ½-inch return. From 100 square feet to 200 square feet, 1-inch flow, ½-inch return. From 200 to 300 square feet, inch and a quarter flow, ¾-inch return. From 300 square feet to 500 square feet, 1½-inch flow and ¾-inch return.

Those are the risers. The mains governing the risers would be on this plan:

From 100 to 300 square feet would be a short vertical pipe from the boiler, 2 inches. Continuing, the starting main would be horizontal; 1½ inches; the return, corresponding to that, would be ¾ inches. From 310 feet to 500 feet, the short pipe rising from the boiler would be 2½ inches, the horizontal main 2 inches, the return main would be 1 inch. From 510 to 900 square feet, the short pipe would be 3 inches, the horizontal main would be 2½, and the return would be 1 inch. From 910 to 1,500 square feet, the short pipe would be 3½, the horizontal main would be 3 inches and the return would be 1¼ inch. Shall I go on?

The President: I might ask Mr. Trachsel whether those are theoretical figures or figures in actual practice.

Mr. Trachsel: They are the actual figures. This drawing for the vapor system would be a little different. (Referring

to the diagram of Mr. Barron and illustrating that diagram.) Here (indicating) is a condensing radiator, so that the vapor passing through these returns would be condensed before entering into this connection which is in the chimney. This air pipe is in the chimney and the suction from the chimney draws all the air out of the system. These instalments have been very successful.

Mr. Wolfe: That is really the German system.

Mr. Trachsel: I believe this is like the German system.

Mr. Gormly: I would like to know whether he finds any trouble with core sand in the small pipe. I had an experience the other day. We washed it out and I took a wooden pail full of core sand, some came from the radiators and some from the boilers. I imagined in a plant of this kind that with such a very small pipe there would be a great deal of difficulty in this way.

Mr. Trachsel: It makes a vast amount of difference—some little projections might be inside the pipe, as we notice in our regular use of the steam pipe—there is a little raise, a blister. That interferes with it and creates a friction and trap and the radiator will not work. It shuts it off as positive as if you turned the valve off. You require a good pitch, a clean pipe, and there is no trouble.

Mr. Lyman: In a system of that kind would the condensation of water in such small pipes on flow and return bother you?

Mr. Trachsel: I should say no. The amount of condensation is so slight; you can notice the amount of condensation passing into the receiver, which would be represented by the thickness of a straw. Of course, where you wish to accommodate yourself to the lower atmospheric temperature, the outside temperature, I should say below zero, you would necessarily put in more radiation and have more condensation.

Mr. Smith: I wanted to say that some of these systems are copied from the German. I think it has been demonstrated that the German systems have been taken from the American systems several years ago. They are practically direct revisions of the Tudor systems.

Mr. Paul: In the first place the Tudor system—I do not suppose that in this country, where the Tudor system originally started, it is in operation. But Tudor patented the principles

underlying this system and he had the radiators connected in the same general way, but he put his condenser on the return pipe or the air pipe, or whatever else you call it, before it came to the main return. Tudor's patents are open to the public. They show he did one other thing; he sealed the return so that he could not only control or govern the quantity of steam that went into the radiator, but he could also govern the temperature of the radiator; that is to say, to illustrate (illustrates on blackboard): He would bring the return down one floor and a check valve would be placed on it at the next floor below. As a consequence the steam that went into the radiator would condense and form its own vacuum and by that means he could circulate steam at very low temperatures, depending upon the drop. I do not think that Mr. Tudor ever put it in a complete working plant. I have never been able to find one. The whole principle is shown in the Tudor patents. There is one thing that has not been said here in regard to the regulation of the valve. You let a certain amount of steam in. That is all right, but if the condition of the room was different the amount of that radiator in operation would be governed by the condition of the air surrounding it. If the room was warm and did not require much heat, the same amount of steam would fill the radiator to a larger extent. The whole basis of this system is not, as it is supposed to be, the suction of a chimney, because the suction of a chimney does not amount to anything. It will not do any work. The whole basis of this system is velocity, the flowing of the steam between two given pressures. You have a pressure of one and a half pounds or two pounds and steam flows into the atmosphere at the rate of 500 feet per second. You have atmosphere in the radiator and two pounds here (indicating) and by governing the flow of the steam you merely govern the quantity supplied.

The question of the system is not this pipe (indicating), as this pipe does not do any good at all as far as I can see. I have not been able to find it so. If anybody can explain otherwise, I would be glad to hear the explanation. If this condenser is a condenser it would have to pull from the chimney as well as pull from the system. The total draft that we can get from a chimney is only two to three inches of water; that is the total suction of a chimney. If you reduce the pressure

by a condenser you can make a great deal more suction than that.

Mr. Barron: Mr. Gormly brought out a practical point. The pipe has to be reamed out. There are not to be too many bends in it; we have found that in the Paul and other systems where air is moving it becomes an accurate matter. That cannot be too much insisted on. The pipes have got to be clear and proportioned right. You must not have too many bends or joints.

A Member: I would like to ask Mr. Trachsel whether he used the radiator for steam in the same proportion as for water.

Mr. Trachsel: Suppose we take the ratio of the radiation cubic contents—water one to thirty-three, and steam one to fifty. The vapor comes directly in between. As to Mr. Paul's remarks, I have in my store a ½-inch quick opening valve and to show the suction there is I held a candle in front of that valve; it actually draws the flame of a candle, is carried horizontally into this ½-inch valve.

Mr. Paul: Where is it carried?

Mr. Trachsel: To the receiver and from the receiver to the chimney.

Mr. Paul: Is it connected with a radiator?

Mr. Trachsel: It terminates with the return pipe and that receiver is connected directly with the chimney.

Mr. Paul: Do you turn the radiator on?

Mr. Trachsel: Yes. The radiator is open at all times.

Mr. Paul: Whether vacuum is from the radiator or chimney?

Mr. Trachsel: It is advisable that this very suction pipe entering into the chimney shall come in contact with the heated gases.

Mr. Barron: When I heard Mr. Debesson's paper read, it occurred to me that we might apply to a low-pressure heating system, a modification of this system, or the ordinary single-pipe system might be improved. This is a low-pressure heating main, a continuous main, with risers taken out. Instead of the main being dropped, it is brought into the top of the boiler. You exclude all backing up of water and sealing of the risers. The end of the continuous main is reduced. You double the capacity of the pipe. I put up an apparatus and it

worked very satisfactorily. The main goes around the building and instead of dropping to the water-line, it goes to the top of the boiler. There are hundreds of modifications of work done of that kind every day. In that way, the ordinary steam main which is too small could be cured. Instead of dropping into the water line, drop into the top of the boiler. Conditions come up when you have to do work in that way.

Mr. Webster: I have been interested in that sort of business. From my knowledge of the Broomell system, which is limited, I fail to find a vacuum, for the reason that the return line is in the equilibrium with the atmosphere. When you open a graduated valve in the top of the radiator, when the radiator is cold, it will allow of sufficient steam to enter and heat that radiator. After the radiator is filled with steam and the surfaces are hot, the steam will begin to circulate down the air pipe, and if you moderate the temperature below the steam will back into that radiator, and the fact that the return line is in communication with the atmosphere or flue, any displacement occurring in that would be filled with the gases or air in that way.

If the other system were considered, it would be necessary to carry the pressure sufficient to blow out the water seals, so that the line of demarcation is closely drawn for the operating of the apparatus. First, on account of the pressure necessary it must be above atmospheric pressure, since the return line is in equilibrium with the atmosphere. If it is above atmospheric pressure the graduating device will have to be delicately handled. In such systems that I have examined, there has been a third circuit of steam into the flues. I had the pleasure of examining this with Mr. Broomell when he first called my attention to the system. It is a good thing in its way, but there is a good deal of difference between the supply and return. By having a valve to prevent the steam from short-circuiting you get greater range and would have an operative device, one that has to be operated above the atmospheric pressure. It is impossible from the explanation made, according to my limit of understanding, how it would be possible to run that system below atmospheric pressure throughout.

Mr. Trachsel: I unfortunately said vacuum system. I used the word "vacuum" instead of "vapor." I meant a vapor

system — don't call it a vacuum system ; it is a vapor system.

Mr. Dean: We had one particular job that we ran just as that lower right-hand sketch shows. We found that when we fired up lively the water would leave the boiler; while you counted five, it would be entirely out of sight. We could not remedy it by the relief pipe, as Mr. Barron shows. We lowered the return pipe down below the water line, and we had no further trouble. The boiler I spoke of had vertical sections and water-legs; the sides were perfectly vertical in the firebox and on the outside of the boiler.

Mr. Lyman: What difference would there have been at the end of this line, if it was simply disconnected? He would then have had the spider-legged, one-pipe system. What is the advantage in making the entire circuit? Why not return it a little higher?

Mr. Barron: That is a very good criticism; I think the gentleman is right. The steam can go both ways. It is very convenient in proportioning the areas to the work to be done and allows you to use a smaller pipe.

Mr. Paul: There is one thing Mr. Kent asked a little while ago that I think covers the question: Does the water go out of the boiler from this lower right-hand corner? (referring to blackboard). It depends upon the velocity of flow in those pipes. We have a velocity of flow in our steam pipes which is of a certain amount; we have practically in a return pipe no velocity of flow where the pipe is sealed. The minute you take that return pipe out of the seal you then have a velocity of flow in the return pipe from the boiler, if it feeds steam to the heating system. The trouble occurred when they were doing a large amount of work; at that time the velocity of flow was increased. If you will hold water in your hand, then turn your hand up and try to blow the water, you can hold a ridge of water until you have quite an incline. If you have a velocity of steam over the water, you hold it up until the pipe is filled.

Mr. Carpenter: We are after improvement in the line of heating either to make heating more satisfactory, or to decrease the cost of construction and operation. I realize from my own experience that the vacuum systems will decrease the cost of operation. I would like to ask Mr. Hauss whether the

system he speaks of decreases the cost of operation, or if not, wherein is a benefit derived. I would like to ask Mr. Trachsel in what way we are getting benefits from the different systems. Does the German system cost less in construction, or in operation?

Mr. Hauss: It is because of the better and simpler regulation that the system is in universal use in Germany. They must use two pipes, and as for the difference in cost between this and the one-pipe system, it should be about the same for material, though the cost of labor would naturally be more.

Each separate radiator can be regulated with the fractional valve, which is not possible with the single-pipe system; then the open air pipe permits the venting of the radiator without having the air escape into the room. An air vent of any kind is objected to, and in fact there are laws prohibiting the use of air valves in the rooms.

Mr. Carpenter: You would class that system alongside of our regular water system?

Mr. Hauss: Yes, as far as the temperature of the radiator and the wide range of regulation goes, but you have much better, surer and quicker regulation of each separate radiator. There is no more radiation necessary for this so-called German or French system than for the American single-pipe system, even though some people now using the system insist on using larger radiators, having named it a vapor system. At this point I would like to say that the open air pipe, fractional valve system of steam heating is really the invention of an American, that is: Mr. Frederic Tudor of Boston. It was then carried to Germany by Mr. Kauffer of Mayence, who had it patented there as his system; then the Frenchman copied it and called it the French system. However, Mr. Tudor was the originator, hence it should be known as the "Tudor system."

Mr. Trachsel: Answering Mr. Carpenter, it runs on a line with hot-water heating, not that the erection would cost as much, but on account of the royalty paid it brings it up on a par with the hot-water system. If a person asks you which is the cheapest system of the two, they are about on a line.

Mr. Webster: I should like to ask Mr. Trachsel whether it would be possible in that system to maintain, say five pounds

of steam pressure in the radiator at the top and modulated in the temperature below feeding from the steam riser line with the same vapor system.

Mr. Trachsel: It does not run up as high as five pounds. It goes by ounces and the limit is 11 or 14 ounces. You have sufficient heat units passing in the radiator which would be admitted through the opening of the valve.

Mr. Barron: There is one feature here. All the condensation in the radiator never returns to the boiler. It is reëvaporated in the riser and main; that should not be forgotten; you do not have to reëvaporate; it is reëvaporated by contact with the steam.

Mr. Carpenter: As to the relative economy between the vapor system, either water and steam or low pressure?

Mr. Trachsel: I can only touch on that point lightly. I had a hot-water system in my store; we used one bucket of coal a day. Since using vacuum, I use half a bucket.

The Secretary: I should like to ask Mr. Trachsel if he uses a steam boiler with the half bucket of coal?

Mr. Trachsel: I use a steam boiler. The point is here—whether we do not give it a little more attention than the hot water, because we want to show it.

Mr. Barron: I do not think there is any difference in the cost of construction or in cost of running. That is my personal belief. We have all put up duplicate apparatus, same boiler, same radiator, same work, and one job of the same size will not burn the same amount of coal as the other.

TOPIC NO. 2.

"How much vacuum can be produced on a steam engine by using the exhaust steam (through a heater) for warming the water of a water-heating system, circulating either by gravity or by the aid of a pumping system?"

Mr. Paul: You certainly would not heat the hot water above the temperature of the steam that you are exhausting, and the temperature of the steam that you are exhausting is governed by the vacuum produced in the engine. It, therefore, seems to me that the whole question resolves itself into: at what temperature do you want to circulate your hot water?

TOPIC NO. 3.

"What is the relative economy of a hot-water heating system using the exhaust steam to heat the water compared with using the exhaust steam direct in the radiators by aid of some air-extracting apparatus?"

Mr. Kenrick: I would like to ask Mr. Mackay if he did not have such an undertaking in the mission church at Roxbury, Mass.?

Mr. Mackay (Secretary): Yes, I had. It came about in this way. The church was formerly heated by steam and the occupants wanted hot water and I helped them to get it. It was very satisfactory, but a good many friends in Boston thought steam would be better and they built a larger building, a separate building to be used as a theatre or young men's hall. They put in a power plant for electric lighting, pumping, etc., and they concluded that they would use this exhaust steam largely for the heating of this new building. They put in a vacuum system, also added it to their school and convent which had already been erected, but in connection with the hot-water part, they did not want to give that up. They extended their hot-water mains 100 feet to the power house, put in a heater, heated the water by exhaust steam, and after some experience in heating the church by this and the vacuum system in the school, they left the vacuum system in the convent and school and removed the entire new apparatus, which they placed in the new theatre and replaced it with a hot-water apparatus, heated from exhaust steam. That has been running five years and they claim they get better results in their church and large theatre with hot water heated by exhaust steam than they do with steam in the school and convent. The question of economy has never entered into it, but the uniform temperature and ease of management seem to be a point with them that makes them prefer the heating by hot water from exhaust steam. They say they like hot water heated from exhaust steam better than the fired system of hot water from boilers.

Mr. Kenrick: I would like to ask him one other question. He might lead the audience to believe that that theatre was heated by direct hot water. Is that a fact or is it heated

largely by indirect radiation—the air blown by a fan over the coils and then by galvanized pipe into the theatre?

Mr. Mackay: That was the original design of the apparatus for hot water, and afterwards for steam, and later for this exhaust-heated hot water. They not only blow this air into the hall by a fan over indirect radiators, but extract the air by two separate fans.

Mr. Barwick: I would like to ask Mr. Mackay regarding the hot-water system if it flows by gravity or whether pumped.

Mr. Mackay: The mains for the church are 450 feet long and those in the theatre are something over 300 feet long. It is an open-tank gravity system with a 60-foot head.

Mr. Kenrick: I would like to ask where the open tank is located. Is it not a fact it is a closed heater in the basement of the power house and exhaust steam flows into that?

Mr. Mackay: The heater is connected with the open tank; there are two closed heaters in the power house, one for the church and one for the theatre, but they are both connected with an open tank. It has an automatic water-supply and an overflow pipe.

Mr. Paul: At what temperature are they circulating that water? As I understand it, the exhaust heats the water. Also I would like to know how much pressure they are carrying, if any, on the steam.

Mr. Mackay: They circulate the water at from 150 to 180; never exceeded 200 degrees in my experience. They have an exhaust system which they purchased and paid for. They are using that, drawing the steam from the heater.

Mr. Paul: How much back pressure on the engines?

Mr. Mackay: There is said to be a vacuum on the engines. I did not see it.

Mr. Bishop: What is the relative economy? I have not heard anything said about the economy of the system or comparative economy between the use of hot water for heating the fluid and heating the building as compared with using steam direct.

Mr. Paul: I suppose the question of economy means how many pounds of coal it takes to supply a certain amount of surface for 24 hours. I have never been able yet to find what the hot-water men, using either the pumping or the gravity

system, claim as to the amount of coal necessary to take care of a square foot of surface for 24 hours. Now, I might say that with an air-moving system a large number of buildings can be shown where the steam has circulated directly from the boiler or from the exhaust and in which one quarter of a pound of coal only is necessary to take care of a square foot of surface for 24 hours.

The President: That is the kind of information the topic calls for.

Mr. Carpenter: I would like to hear some one who has had experience where there isn't an air-moving system, who has made the test, and what the results have been.

The President: Will any one answer?

Mr. Bishop: I think it would be difficult to answer. I have made a great many tests. It depends entirely on the temperature of the room and the temperature outside as to the amount of coal consumed. It takes so many units per hour to keep it up. It is a question of delivery and economy. The actual amount of heat required is the same in all cases. I have known it to go as high as four pounds of steam per hour and as low as one-eighth of a pound, depending entirely on inside conditions, and the temperament of the occupant of the building as to being wasteful or otherwise in the use of heat.

Mr. Paul: Mr. Bishop has had a great deal more experience than I have, in testing plants, he being in that business. I think some of his statements are a little misleading. They are to me, because my experience has been entirely different. I find one governing point is the temperature at which you are circulating the heated medium, and another governing point is the amount of radiation installed to heat a given space. If you put in a certain amount of radiation to heat that space you will use $\frac{1}{4}$ of a pound of coal for 24 hours per square foot. If you put less radiation in to heat that space, you will use more per square foot of surface under the same conditions; but the economy of the operation depends upon the relation of the temperature of the heated medium to the temperature of the air to be heated.

Mr. Bishop: I was basing my assertion on actual running conditions, not of a test condition. Mr. Paul would have a

building entirely closed, to have a test made as he refers to. I had in mind the actual condition as it is in the house. While the average consumption in this climate of fuel for steam is 900 pounds per season, I have known it to go to 965 pounds in a single month.

Mr. Paul: The statement I made is based on absolutely running conditions, and the first test that produced that result was a test on a building in Milwaukee which sets so that all sides are exposed, and the temperature, if I remember correctly, averaged about 13 degrees above zero on a three-days test. One day it was 188 above, when they tested the plant without any air-moving system, but with a thermostatic regulation system that kept the temperature of every room in the building at a uniform temperature. The second test was made with an average temperature of, I think, 12; the third test was made with a temperature averaging only 5 above zero. Those three tests were checked, so that there was no question about them. Two were with an air-moving system and one was without. Now, we have a building in New York City which is heated by direct radiation and is heated directly from a boiler on a low-pressure gravity system that has 8,000 square feet of surface. It does not use a ton of coal per day and has not throughout this winter so far.

Mr. Mackay: This particular building that I referred to in Boston has 8,000 feet of direct radiation and a million and a quarter cubic feet of air-space, and it has been shown by four or five winters running under fair conditions that but an eighth of a pound of coal per square foot of radiation for 24 hours has been used.

Mr. Bishop: I want to ask one question: Did Mr. Paul find in the temperatures of 18 and 13 and 3 outside, there was no difference in the amount of steam used per square foot?

Mr. Paul: There were 2,700 pounds less coal used at the low temperature than was used at the high. [Laughter.] The higher temperature was without an air-moving system and steam was used at a pressure of 2 pounds, an average of 2½ pounds, while with the air-moving system, the pressure was about atmosphere. The record of this test is given on page 270, vol. III., 1897, Transactions of this Society.

Mr. Kenrick: That statement of Mr. Paul is on the same

line as a statement made last year by a gentleman here, that with a smaller pipe the better service he could get.

Mr. Carpenter: I know of one case where a good-sized manufacturing plant using an air-moving system, where the actual amount of coal used in winter for heating and for manufacturing purposes is less than it is in summer. [Laughter.]

Mr. Paul: I think this question is a pretty hard one to answer, but, of course, we have been going into it and experimenting considerably in the last two or three years and our experiments have proven that it is absolutely impossible to use as much steam to produce the same results when the pressures are reduced as you would use when the pressures are at a high point.

Mr. Carpenter: Maybe I had better explain. Some may think I have stretched the point. [Laughter.] It is, according to the man in charge, an actual fact, and the reason of it is as follows: The exhaust is taken from two engines located probably 600 feet apart. The pipe connecting the two engines and the water heater runs through the building. This line of pipe also supplies the radiation. The buildings would become overheated in summer if the exhaust were run through this line of pipe. To avoid this the exhaust from one engine was thrown away, the exhaust from the other engine being used in the water heater and not being sufficient to heat the water from the mains to as high a degree of temperature as is returned to the boilers in winter when both exhausts are used, requires more coal.

Mr. Paul: The reports on the Park Row Building are that they use less coal in the winter time than in the summer.

Mr. Rutzler: Regarding the Park Row Building, Mr. Paul has given the matter more time and consideration than I have been able to do. I have fulfilled my contract, received my money, and have let the other gentleman attend to the rest of it. However, it does seem remarkable that it should take less coal in winter than in summer to run this plant. [Laughter.] I could not offer any definite reason for this state of affairs without making close investigation into all phases of the case, but there is certainly a good deal of waste in the summer in the way of heating and in the way of condensation from the engines, which is a considerable benefit to them in the winter season.

TOPIC NO. 4.

"What is the advantage (or disadvantage) of broad grates with shallow firing over deep fireboxes and intense concentrated fires on small grates in hot-air furnace heating?"

Mr. Kent: The advantage of broad grates, whether shallow or deep firing, is that we can burn the coal with less draft, requiring lower chimneys. We will also accumulate a smaller amount of ashes on each square foot of grate and there is less danger of forming clinkers; everything is in favor of the larger grates. The greatest mistake in large plants is that so much boiler heating surface is piled above the grates, making it necessary to drive the fires hard with a greater accumulation of ashes and greater amount of choking of the draft by the ashes. I am entirely in favor of as large a grate as is reasonable. Of course, when slow combustion on a small grate burns all the coal that is required to give the amount of heat needed, then the small grate is all right.

The Chairman: The liberty of the floor is given to our invited guests. Is Mr. Kaiser here? Would he like to say anything on this subject?

Mr. Kaiser: I do not know much about the subject. My opinion is that the broad grate and shallow fire will carry a larger amount of radiation surface, or heating surface, as you call it. As against that it takes a man steadily to keep the fire in good working position; in large plants that is not so much an objection. With deeper fires it would take less attention.

Mr. Carpenter: It is a curious subject, whether the plant is a small one or a large one; the smaller plant requires so much more attention that we use a deeper fire-box than we would with a large one. I think that a great deal of trouble and expense is on account of having a deep fire in a large boiler plant. A great waste is made, and it is very difficult to convince firemen of that waste; they think all they have to do is to throw in the coal and they have a fire there.

Mr. Smith: It should be borne in mind that you do not run your apparatus to the full capacity. With a large grate I have seen a good many cases where a man has tried to run the fire and he had a lot of trouble; he can reduce the capacity of his

plant temporarily, with the conditions of the atmosphere and the temperature better with a small grate and deep fire than with a large grate and shallow fire.

Mr. Lyman: There is one feature in this warm-air work which has not been alluded to. All manufacturers, in making a fire-box, taper it upwards, making the grate of much less surface than the top of the surface of the fire. The reason for that is that we can carry a much smaller fire than in the ordinary boiler plant. We can carry a larger quantity of coal and require much less attention by having a narrow grate.

Secretary Mackay: My opinion is that this particular question is asked in connection with house-heating plants, where they have no engineer and where self-feeding plants are going out of existence and we want something to run from 6 to 8 hours without attention. My experience with that style is that a deep fire, under slow combustion, gives better results than a shallow fire requiring attention every two hours. I think that this is the experience of the majority of those who have been connected with plants for heating buildings, where little or no attention is given to the plant. They want to throw on enough coal at one time to carry it for eight hours. Manufacturers have frequently guaranteed that a plant will heat a building with attention three times every 24 hours. It is to meet such conditions as that that deep fire under slow combustion will give the best results with least attention.

Mr. Wolfe: For house furnaces and heating air—that is all right. Regarding the slow fire, I agree with Mr. Mackay, but when we talk about deep fires we get away from furnace construction. Every furnace we have in a single fire-box is upside down, and the result is this: it burns the coal in the centre where the draft is travelling vertically; there is a layer of ashes between the fire and the outside fire-pot, and they practically have to heat anywhere from two to eight inches of non-conducting material. I believe that the deep fire with perfectly fitting damper below would be the best construction that we could get for furnaces.

Mr. Oldacre: I would like to say a few words about the subject. I made experiments on it. I took the same hot-air heater and made the same connection with the same chimney in the same building, taking the temperatures every day. The

thermometer was kept running six weeks. I took the temperature of the gas and the temperature of the hot air and of the incoming air each half hour from 7 o'clock in the morning to 4 o'clock in the afternoons. I also weighed the coal. I used broken, pea and stove coal under different conditions. I can say to you that the experience I had—I carried the same amount of heat with 56 pounds of coal per day as I was doing before with 140 pounds. Fifty-six pounds of coal consumed per day by deep fires and 140 pounds of coal burned in the same furnace, under same conditions, using the same heater with a shallow fire. We had to put on coal oftener because of the draught. The less attention the heater or boiler requires in the house-heating plant the better it is liked; the less there is for a person or servant to do. The next thing is, unless there is much reserve in cold weather the heater is liable to burn out in the night. A great deal of trouble I find is this: a heater to be large enough for the most severe weather is, as you know, too much for moderate weather.

Mr. Gormly: We had a building, the water being heated by a water-back in an architect's house. We first arranged it with a water-back, surface vertical in the fire. We found that we could do just double the work with the same water-back with the same radiation and piping. The water-back was probably ten inches in depth and that inclined about ½ inch at the top toward the fire.

Mr. Oldacre: I would like to say that I have had experience with combination heaters. The best illustration that I can see of the difference between deep fires and slow combustion against shallow fires and rapid combustion can be seen in the combination heater. If the heating surface for the water part of the combination is in the fire or close to it, the heat is kept up continuously throughout the pipe. If that surface is suspended over the fire there is practically no circulation that takes place in the hot-water part. It is a combination between the two, having the surface in the fire and out; it will be seen that the surface of radiation which corresponds to the total amount of heating surface will be very inefficient in the manner in which people ordinarily run the heater. I would also say in this connection that in one house we heated I made tests of the temperature of the air coming through each regis-

ter in each room throughout the house for eight days, also that I not only depended on the thermometer hanging, getting the temperature of the room, but at least a self-recording thermometer in the house, keeping an average temperature in the house during the time I was not there. That also showed me that there was a great deal more coal being burned by rapid firing than by allowing the heater to be used by the method of a large body of fire with a slower rate of combustion.

Mr. Paul: I would like to ask a question. Do you know the temperature of the gas coming up the chimney in those cases?

Mr. Oldacre: The highest temperature of the heat itself going through the pipe was 240 degrees; at the same time the gases were passing out the chimney I believe at a temperature of about 320 degrees. The lowest temperature I had recorded as coming from the heater was 98 degrees, and at that time the temperature of the gases was lower than the heat going through the pipe. I think the temperature of the gases passed out at that time was 78 to 80, because the fire was almost out of the heater, early in the morning before the coal was put on and the heat that was really coming through the heat pipe was due to stored heat in the surface heater.

Mr. Lyman: Referring to what Mr. Wolfe says, I hardly think that in the ordinary furnace construction there would be 6 inches of ashes on the sides of the pot. There are some furnaces with the fire pots reversed, and I do not think they are any more successful. The difference between the grate and top of fire pot varies from 2 to 6 inches, in cases that I am familiar with; but, if Mr. Wolfe has seen a fire pot with 18 inches difference, I will modify what I said. It is possible that he has. I know of illustrations which have been used showing the ashes accumulating from a line drawn directly from the edge of the grate to the top of the fire surface, but my practice has never borne out that there is any such accumulation in a fire that is carefully stoked.

Mr. Wolfe: As a matter of information I know that an 18-inch grate, round pot is sold to the innocent public as a 36-inch pot furnace. There is one shrinkage off, but practically there are 35 inches in the clear if you put a rule on top of the pot.

There is a difference of 17 inches, half of which is 8½—certainly the natural result of a fire. We all know that in circular pots the fire goes out in the centre last. As it goes out the accumulation of ashes becomes thicker on the edge and the outer part of the fire-pot is hotter.

Mr. Oldacre: I have had experience with the fire chamber; it has a Smith pattern of grate and by rotating the grates in one certain direction the ashes bank against the side. By simply rotating the grate in the opposite direction the ashes were entirely removed from the fire-pot and the effect of the heater was greatly increased, so much so that in all cases we give instructions that they must rotate grates in certain directions.

Mr. Kent: I believe the American heating and ventilating engineers have been building hot-air furnaces for 100 years or less and this discussion shows how very little they yet know about them. If I had the facilities of the Imperial Technical Laboratory in Charlottenburg, Germany, or those of the proposed Carnegie Technical Laboratory in Pittsburg, I think I could solve many of these questions. [Making diagrammatic illustration on blackboard.] This represents [indicating] anybody's hot-air furnace with the air going into the fire and gas going into the chimney. Here [indicating] is the air going into the heater and here [indicating] shows it coming out hot. I would measure the air going into the fire and analyze the gases that went out. I would pass these gases through a chamber built of brick or wood, lined with asbestos, containing some thousand feet of condensing surface; I would have ice water at one end and hot water at the other. I would put on a recording meter and thermometer and would have a continuous record of what the temperature was going out the chimney and an analysis of the gases, and of the quantity of air entering the fire. On the other side I would measure the cold air going in under a certain pressure to be heated, to know how much air is coming in; and here [indicating] we take its temperature going out, and then we would cool it by a refrigerator apparatus. There we would obtain the heat units going out the chimney and the amount of carbon di-oxide gases. Thus we would have the whole story. Then, we would experiment on all kinds of fire boxes or fire-pots. After study-

ing that thing and one or two others, we might get some scientific principles. This shows how difficult it is to make a scientific test.

Mr. Lyman: How would you arrange to have a normal condition of draft with your condensing apparatus on the smoke pipe?

Mr. Kent: I would put water gauges there and test with all possible kinds of drafts. By having a blower we could get any volume or pressure of draft desired.

Mr. Wolfe: I would like to see that drawn out and submitted to the members for tests such as we would like to make. That is the clearest thing I have ever seen.

Mr. Kent: It would cost about $1,000 for the apparatus.

Mr. Wolfe: I have seen $1,000 wasted on less stuff than that. I would like to tell you, gentlemen, regarding a furnace I had seen advertised extensively in France. They had an establishment, and it was not less than $3,000 a year for their show-room. I went in there and said that I would like to heat a room or a house—a suburban house—that would be seven or eight rooms, and asked them to show me a furnace of the size they thought would be right and proper with which to do it thoroughly and well. They showed me one, with all kinds of guarantees, and the fire-box of that furnace was 7x18x12 inches. That was the fire-box! That is all the coal you could get in. They guaranteed it in the coldest weather.

TOPIC NO. 5.

"What can we do to impress upon owners of buildings and architects the necessity of adequate smoke flues for heating apparatus?"

Mr. Rutzler: The question of a flue is a very simple one. There could very readily be a standard fixed for the heating and ventilating engineers of the United States, naming a certain area of flue for the various sizes of boilers. I have often, in conversation with an architect, been asked the necessary flue area to accomplish the desired amount of draft. There have also been cases where I have been very seriously injured through this matter of the flue not having been considered properly in advance. I feel that if a standard were to be set

for a water-tube boiler, it would answer all purposes. I recall one case wherein I came in contact with a flue which I supposed to be of ample capacity to provide draft for a special kind of boiler to be installed, of 150 horse-power. The boiler people made a proposition, which I accepted, without, however, having read the footnote, calling for $\frac{5}{8}$-inch draft, 150 horse-power. After being installed, I was unable to get 25 horse-power out of the apparatus. I went to the maker of the boiler, and I knew that he guaranteed this boiler 150 horse-power, but could not get anything near this amount. His reply was, "If you will give us the draft, we will give you the power." I replied that the draft was provided for when the order was placed, and that he knew the conditions of the building. His answer was: "Read my proposal." Upon closer scrunity of the same I found it called for "$\frac{5}{8}$-inch draft." Up to that time I had never quite appreciated what draft was; but I assure you now, my experience has taught me that is is a very important question. I therefore make it a practice in giving an estimate to anybody to insert a clause "that the owner is to supply a flue of ample capacity for the boiler to be installed."

Mr. Snyder: The only cure for this condition of affairs is in interchange of ideas between this Society and those devoted to architecture. I believe one of the best methods to bring this about is for the Society to invite the members of the American Institute of Architects to attend the next annual meeting. You had with you at our banquet the President of the New York Chapter of the American Institute of Architects, one of its most prominent memebers. If you can secure the attendance of such men at the meetings, that they may learn of the broad scope of the work aimed at by this Society, I believe they will meet you more than half way. The source of the defects in architect's plans complained of lies in the fact that only in some instances is an architectural student given any instruction along these lines. I speak from experience, as I have some forty-six architectural draughtsmen now in my employ, and not one of them knew even the rudiments of ventilation, and since it is embodied in all of our work their first six months of service was of no great value.

TOPIC NO. 6.

"What is the proper proportion of grate surface in a boiler to radiating surface in a building in a low-pressure steam and in a hot-water heating system?"

Mr. Hamlin: This question has appealed to me a great many times, just as the question disposed of a few minutes ago as to flues.

Mr. Cary stated the architects were persistent. When I was an operating engineer, I also found them persistent and have asked what size boiler or flue they would suggest. They did not know where to go to find out to specify boilers for particular cases, there being no authentic tables.

The engineer contracts to put in an apparatus as specified and finds he is obliged to supply a larger boiler than he figured at the same cost. Te eliminate this trouble, I would suggest that this question be given to a committee. I do not think it should be given to the Committee on Codes, as they have their hands full now.

We should have a list that can be published and is something that an architect may accept and know he is right, then I think we can accomplish something, and such a series of tables will do the association a deal of good and also be of invaluable assistance to the architects.

I would like to see a committee take up this question and report at the end of the year.

Mr. Barron: I do not think there could be a more important question than this of heating surface and grate surface. It is one thing you cannot find out. I was with a concern who manufactured boilers years ago—it was a subject we would not tell; we wanted to avoid it. It is something retained by the boiler manufacturer to-day; I speak of the whole trade. The heating engineer wants to know how many square feet of heating surface you have; how many square feet over the fires, flues and tubes, and back connection.

Mr. Harvey: I agree with Mr. Barron in the statement that there is no subject that would be more useful than this one. As Mr. Barron says, every manufacturer of boilers does not care about showing just how many square feet heating surface his

boiler contains, for fear some other manufacturer would claim a few more feet on the same grate surface. It is a fact, you can get a certain result from a given amount of coal burned per square foot per hour. The point is to get that heat distributed over the heating surface in the best manner. There is a great deal of heating surface in many boilers that is practically useless.

Mr. Barron: Steam fitters, a good many of them, go on the basis of one square inch of grate per square foot of radiating surface; one square foot of grate surface equals 144 feet of radiating surface. Those are the facts for boiler men to consider; the heating engineer does not go by the catalogue.

TRANSACTIONS

OF THE

FIFTH SEMI-ANNUAL MEETING

Atlantic City, N. J., June 16, 1902.

C.

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS.

FIFTH SEMI-ANNUAL MEETING,

Held at the Hotel Rudolf, Atlantic City, N. J., June 16, 1902.

PROCEEDINGS.

FIRST SESSION.

The meeting was called to order by the President, Mr. Alfred E. Kenrick at 10:45 A.M.

Secretary Mackay: Before calling the roll, I would announce the names of the following members who have been elected since the last meeting:

NEWLY ELECTED MEMBERS ANNOUNCED AT THE ATLANTIC CITY MEETING, JUNE 16, 1902.

Albert B. Franklin	Boston, Mass	Member.
Frank Dobson	New York	"
Wm. C. Vrooman	Schenectady, N. Y	"
A. P. Broomell	York, Pa	"
G. M. Langdon	Hartford, Conn	"
C. M. Lyman	Utica, N. Y	"
J. C. F. Trachsel	Philadelphia, Pa	"
C. E. Oldacre	Philadelphia, Pa	"
J. H. Lindsay	Brooklyn, N. Y	"
Chas. P. Vanderveer	New York	"
Frank P. Edson	Topeka, Kansas	"
Walter Yates	Manchester, England	"
F. M. Mechling	Pittsburgh, Pa	"
Harry S. Martin	Dunkirk, N. Y	Associate.
A E. Pfahler	New York	"
John M. Bruce	New York	"
T. G Haywood	Norwich, Conn	"
C. L. Williams	Chicago, Ill	"
Geo. A. Robertson	Brooklyn, N. Y	Junior.

The secretary then called the roll, and a quorum was found to be present.

The President: Gentlemen, I notice that the next thing on the programme is the President's address. Perhaps it may show negligence on my part to say that I have not prepared any address for this meeting, but I welcome you all to this beautiful city in the State of New Jersey, and hope that you will have a very pleasant time while here. In January I will endeavor to do better in the way of an address. The next order of business is the reading of a paper on "A time limit and dry walls necessary in testing a heating plant," by John Gormly.

Mr. Gormly read the paper, which was discussed by Messrs. Wolfe, Kent, Snyder, Payne, Broomell, Sardou, Wilson, Trachsel, Addams, Oldacre, Kendricken, Chew and Harvey.

The President: Is there anything further, gentlemen, to be said on this subject? If not, we will pass along to the topics of discussion. There has been one topic presented to me: "The tenth anniversary meeting, 1904; suggestions for making it a very notable occasion." Is there any gentleman here that can give us any suggestions as to what is for the best interests of the Society at our annual meeting in 1904? I would like to hear from Mr. Chew, the Chairman of the Committee.

(The discussion will be found under the head of "Topical Discussions.")

The President: The question might perhaps properly be brought up before the Society at this time as to reading the paper of Mr. John J. Harris, on "Cooling an Auditorium by Means of Ice." As Mr. Harris is absent, it is suggested that the paper be read by our secretary, Mr. Mackay.

Secretary Mackay: I suggest that as this paper describes an experiment which Mr. Harris has made, and he told me yesterday that he had made some additional tests in doing exactly the same thing this month, it might be well, if it be not possible to get Mr. Harris here, to answer the questions that might come up in connection with it. Let it go over to the afternoon session, if we have one, or to the evening session.

Mr. Wolfe: I move that the reading of the paper be postponed until this evening. (Carried).

The President: Is there anything further to come before the association at the morning session?

Secretary Mackay: I do not intend to make a report at this time as to the state of the finances. I will say that while we have two volumes of the Proceedings to take care of this year, we hope to issue the 1901 and 1902 volumes of the Proceedings to the members before the next annual meeting. And there has been some question as to the delay in our 1901 volume. That was due largely to not getting the corrected discussions back from the members, but it is all printed in galley form and is in the hands of our editor to make the final corrections and the list of contents, and it will go out to the members positively during the coming month. There are sufficient funds on hand to take care of the general running expenses of the Society and pay for that volume. There are sufficient funds owing to the Society in good hands, possibly to be paid within the next 30 to 60 days, to take care of the additional volume which will be issued this year. As you have heard to-day, we have added, since the last annual meeting, nineteen members to our roll. We have applications on hand for some twelve additional members which have come in since the last ballot, and a number of them at this meeting, so that the ballots going out will give us some additional cash, and it looks as though we would come up at the annual meeting with all accounts paid, the volumes issued up to date and a surplus in the treasury, besides a large additional increase of membership over any previous year.

Mr. Switzer: The report of the secretary is very gratifying. It recalls to mind the discussion at our annual meeting last winter with regard to more prompt payment of dues. I would like to ask if there is any large percentage of members in arrears?

Secretary Mackay: The number that owe more than one year's dues is very small, and some of this amount that is due to the Society is for new members who have just been added to our roll, so that it was not due at the annual meeting, and not due for two or three months after, and they have ninety days to qualify, so that some new members have not qualified as yet. At $25 a member, it runs up to something like $200 incoming dues.

Mr. Switzer: One of the questions I had in my mind was in regard to the contributions the members made at the last an-

nual meeting to relieve the debt. Was that provided for? Were the subscriptions ample to cover the floating indebtedness at the January meeting?

Secretary Mackay: The complete subscription, when it is received, will take care of the entire indebtedness. Mr. Chew brought up one point which might be looked on as a reflection upon the officers, and I would like to make that perfectly clear, and that is in connection with receiving and publishing the papers far in advance of the meeting. Unfortunately, the members who have written papers for the Society, most of them are busy men, and we have not received the papers in time to have the cuts prepared and have them printed. The moment they are received they are passed on by the publication committee and corrected by our editor, and as quickly as the cuts can be prepared and the papers printed I have had them done. But frequently it is impossible to mail them to the members more than one week previous to the meeting, but that is something that is in the hands of the members, not in the hands of the officers, and I would like the members to understand that there has been no delay after the papers have been received, in publishing them. Now, to-day, we have a paper on our programme that has not been received as yet, and that is the condition of other papers that we have had from time to time. We have had papers that have to be read to the meeting in manuscript because we do not receive them in time.

The President: Gentlemen, is there anything further at this time? If not, as I said before a motion to adjourn will be in order.

The meeting then adjourned until 8 P.M.

EVENING SESSION.

The meeting was called to order by President Kenrick at 8:30 P.M.

The President: The first business to come before the meeting this evening will be to listen to some communications in the hands of the secretary.

The secretary read a telegram from Professor R. C. Carpen-

ter, letters from Professor F. R. Hudson and Mr. A. M. Waitt, and from the Buffalo Merchants' Association.

The President: The next business will be the reading of the paper by Mr. Harris, entitled "Cooling an Auditorium by the Use of Ice." In the absence of Mr. Harris, I will call upon the secretary, Mr. Mackay, to read Mr. Harris's paper. Mr. Harris fully intended to be at the meeting, but he was called away this afternoon. He went over this paper with me last Saturday and gave me some data in reference to a later test which was made last week.

Secretary Mackay then read the paper.

Secretary Mackay: Mr. Harris mentioned to me, that under exactly similar conditions of outside temperature and on the 14th of this month, there were 1,600 in the room and he maintained 72 degrees in an outside temperature of 90, and that as an experiment they added about 5 per cent. of salt with the ice this year and found it an advantage, both in lowering the temperature and in reducing the melting of the ice.

The paper was discussed by Messrs. Kent, Chew, Wolfe, Broomell, Mackay, Blackmore, Payne, Addams, Stokes and Sardou. On motion the paper was referred back to the author with the request that he present it at the next annual meeting with more complete data. (The discussion of this paper at the Atlantic City meeting has been withheld from publication in this volume. It will be printed with the revised paper in the next volume—Secretary).

A discussion was then held on the subject of the tenth anniversary meeting of the Society, which is proposed to be held in St. Louis in 1904. It was followed by a discussion on the subject of "The Need of a Laboratory for Technical Research." Mr. Addams then brought up the question of the fulfilment of contracts in which one of the clauses requires that a building be heated to 70 degrees in zero weather. All of these discussions will be found under "Topical Discussions."

The meeting then adjourned.

AMERICAN SOCIETY HEATING AND VENTILATING ENGINEERS, 1902.

List of members present at the Fifth Semi-Annual meeting at Atlantic City, June 16, 1902.

MEMBERS.

Homer Addams.
G. C. Blackmore.
A. P. Broomell.
B. H. Carpenter.
F. K. Chew.
F. P. Edson.
John Gormly.
H. B. Gombers.
Andrew Harvey.
T. G. Haywood.
Wm. Kent.
A. E. Kenrick.
W. M. Mackay.
A. S. Mappett.
H. S. Martin.
J. A. Payne.
D. M. Quay.
C. B. J. Snyder.
W. H. Switzer.
J. R. Shanklin.
H. A. Smith.
J. C. F. Trachsel.
Warren Webster.
J. J. Wilson.
W. F. Wolfe.

AMERICAN SOCIETY HEATING AND VENTILATING ENGINEERS, 1902.

List of guests present at the Fifth Semi-Annual meeting at Atlantic City, June 16, 1902.

GUESTS.

H. S. Alexander.
W. S. Appleton.
A. F. Allen.
W. Bartine.
W. W. Biggs.
C. A. Crequi.
W. H. Clark.
E. F. Coacannen.
J. A. Conley.
Wm. Clark.
M. E. Danforth.
J. S. Dougherty.
W. H. Day.
C. J. Eldafield.
L. E. Feniman.
E. J. Febrey.
J. O. Galloup.
G. F. Gilbert.
A. Geiger.
S. J. Geoghegan.
E. H. Griffith.
H. H. Hellerman.
J. G. Howley.
H. M. Higgin.
R. W. Kyle.
J. K. Keegan.
P. H. Kendricken.
W G. LeCompte.
G. W. LeCompte.
J. I. Lyle.
D. MacCallum.
Wm. McMurray.
E. E. McNair.
A. J. Meyer.
L. P. Marsh.
W. B. Moore.
N. H. Nelson.
T. J. S. Nicely.
G. Neugle.
W. C. Ogden.
R. W. Ryan.
E. H. Roberts.
W. G. Sellers.
M. Sardou.
H. F. Sherriff.
L. B. Scull.
E. L. Stock.
C. M. Stokes.
E. R. Spence.
F. J. Shaler.
S. C. Smith.
G. F. Uber.
C. F. Webber.
G. H. Zeller.

CI.

A TIME LIMIT AND DRY WALLS NECESSARY IN TESTING A HEATING PLANT.

BY JOHN GORMLY.

(Member of the Society.)

The writer had an opportunity to make partial heating tests in a new building during the past winter. While the tests are incomplete, our Society is here given the benefit of the data obtained, because they appear to have a direct bearing on our proposed heating code in its practical application.

The building tested is a three-story and basement dwelling. The basement is not heated other than by the heat escaping from the uncovered heater and the main pipes. The first, second and third stories are heated by low pressure direct steam radiators; in all rooms the style of radiator is wall pattern.

The first story and basement are of stone, the second story is wood shingled, the third story and roof are slate. The building is furred on the first story and lined with building paper under the shingles. The house stands on an open lot exposed to winds from all directions. At the time of making the tests the building was without fire for two weeks. During that interval the temperature was for a good portion of the time as low as 20 degrees Fahrenheit.

When the plant was installed, before the walls were plastered, while window and door frames were so loosely fitted into the walls that the hand and arm could readily be passed out through holes between the frames and the wall, 10 pounds of steam were raised on the entire plant in a steaming test, although no window sash were in position; but the window openings were covered with thin muslin to prevent too great an escape of heat. The plant was able to raise more than 10 pounds of steam on the guage; but as the safety valve was set

at 10 pounds, that was the limit of steam pressure raised on a firing test. At this time the outside temperature was about 20 degrees above zero.

As soon as wet plaster was placed on the walls no pressure whatever could be raised to show on the guage, although the plant was fired as hard as possible; the draft was excellent; anthracite coal, pea size, was used; all pipes and radiators were hot to the touch. The wet walls and saturated air appeared to absorb the heat as a sponge absorbs water. Although all holes around window frames were now closed by the plaster, and the building was comparatively tight, we could not show 1 pound of steam on the plant, which showed 10 pounds readily while the building was so very open. The situation was not perceptibly altered after window sash were fitted to the window openings, which up to this time were covered with muslin. The window glass quickly was covered with ice, as the moisture evaporated from the wet plaster froze to the surface of the glass. The plant was run in this condition for several weeks to dry the plaster. After the white finishing coat of plaster was put on and partly dried but still damp enough to be readily indented by the finger the building was left for two weeks without fire. We thus had an opportunity to make some temperature tests. Our tests continued for a portion of two days. The result of our tests is shown in the accompanying table, Plate 1.

Attention is called to the improvement in pressure, and also in temperature, as shown by the second day's test, over the tests of the first day. We will take the readings at 9.30 on each day. The outside thermometer shows an increase of 8 degrees on the second story, while in the parlor we show an increase of 26 degrees, in the first story entry 28 degrees, third story front 30 degrees, and in all rooms we show an increase over the first day's record. A comparison of the first and second days' readings would appear to be conclusive evidence that some time limit should be set in the use of our proposed testing code.

A note should accompany the code, stating that the walls of a building must be reasonably dry to get any fair estimate of the power of a heating plant. It is to be regretted that the party making the test neglected to keep a record of outside and inside temperatures for a longer time on the first day; but as

DEGREES FAHRENHEIT

Time	8	8.30	9	9.30	10	10.30	11	11.30	12	12.30	1	1.30	2	2.30	3	3.30	4	4.30	2d Day in Roman *1st Day in Italic* 12 o'clock raked and fired
Outside *Temp. Deg. Fahr.*	56	56.5	57	*50* 58	*53* 58	*55* 60	*57* 61	*60* 62	63	61		58		58	58	58	56	55.5	
Parlor	71	*49* 73	76	*54* 80	*59.5* 82	*64* 83	*67* 84	*70* 85	*71* 86	*74* 87	*75* 87	87	87	88	88	88	88	88	3-4 P.M. Cloudy Front of House-South Entry to West-ward.
Dining Room	71	*52* 73	77	*56* 78	*62* 80	*67.5* 82	*68* 83	*70* 84	*72* 85	*75* 86	*76* 86	86	86	86.25	87	87	87	87	
Kitchen	68	*50* 70	74	*54* 76	*58* 78	*62.5* 80	*64* 80	*66* 81	*66* 82	*67* 83	*68* 83	*69* 83	83	83.5	84	83.5	83	84	
1st. Floor Entry	70	*49* 72	76	*52* 80	*58* 82	*63* 84	*66* 85	*70* 86	*70* 87	*72* 88	*73* 88	88	88	86.5	89	89.25	89.25	90	
2d. Floor Front	73	*51* 73	78	*54* 82	*61.5* 84	*67* 86	*71* 88	*76* 89	*76* 90	*78* 90	*79* 90	90	90	90	93	93.25	92	94	
2d. Floor Next	74	*52* 75	78	*57* 81	*63.5* 83	*67* 84	*68.5* 86	*72* 87	*72* 88	*74* 88	*74.5* 88	88	88	88	89	89	88	88	
2d. Bath	74	*58* 76	78	*57* 79	*61* 81	*62* 82	*64* 84	*67* 84	*67* 86	*68* 86	*70* 86	*71* 86	86	86.5	87	87.25	87	87	
2d. Rear	72	*52* 72	75	*53* 78	*59.5* 80	*62* 81	*63* 82	*66* 84	*67* 85	*69* 85	*70* 85	85	85	85	86	87	86	85	
2d. Entry	73	*50* 73	76	*51* 79	*56* 80	*60* 82	*63* 83	*68* 84	*68* 86	*71* 86	*71* 86	86	86	86	87	87	86	87	
3d. Front	76	*52* 76	80	*54* 84	*60* 87	*69* 88	*73* 90	*78* 91	*82* 92	*84* 94	*84* 94	94	*86* 94	94	94.5	95	96	96	
3d. Next	74	*50* 74	78	*54* 81	*61* 83	*67* 84	*69* 86	*74* 87	*74* 88	*79* 90	*80* 90	90	*80* 90	90	90	90	90	90	
3d. Rear	72	*51* 72	75	*52* 78	*59.5* 80	*63* 82	*65* 83	*69* 84	*70* 86	*74* 87	*74.5* 87	87	*77* 87	86	86	87	86	85	
3d. Entry	72	*49* 72	74	*50* 78	*52* 80	*57* 80	*59* 82	*62* 84	*63* 84	*68* 86	*69* 86	86	86	86	86	86	86	86	
Boiler Pressure		*0*	*0*	*0*	*0*	*0*	*10*	*6*	*Water*	*2.5*	*1.75*		*4.5*						
Boiler Pressure	0	0	3	6	7.5	7	7.5	9	8.5	8.5	8	8	8	8	8	8	8	8.75	

A TIME LIMIT AND DRY WALLS NECESSARY IN TESTING A HEATING PLANT. PLATE I.

he was not seeking comparative tests and was intent only on finding the highest temperatures he could obtain in the various rooms, he devoted the first day to warming the walls up preparatory to a test to be made the second day.

The horizontal line from 12 to 2 o'clock on the second day's test, the result of cleaning and re-coaling the fire, is apparent. The same effect is shown in the first day's test from 11.30 to 12 o'clock. The relatively higher temperatures of the second and third story front rooms are due to the direct action of the sun from 3.30 to 4 o'clock. On the second day's record the temperature of the front rooms fell because of the passing of a dense cloud. It would appear from the records of this test that no true test can be made where the walls are damp or where an effort is made to complete a temperature test in too short a time. On massive walls which have been subjected to intense cold for a time before the test is made no test of one day's duration will give the temperature readings of what a plant will do continuously.

Hood, in his "Treatise on the Warming of Buildings" asserts that the heat required to raise a cubic foot of water 1 degree Fahrenheit will raise 30,000 cubic feet of air 1 degree Fahrenheit.

This, if true, which appears probable from the effects which were produced as indicated by the chart accompanying this paper, makes the dry or wet condition of the walls of a building a question of moment in the testing of a heating plant.

Walls which have been exposed to great cold for a length of time while in a moist condition are practically to be compared to ice, and the effect of ice in the absorption of heat must be a matter of consideration also, if we are to secure any approximation to accuracy in tests of heating plants.

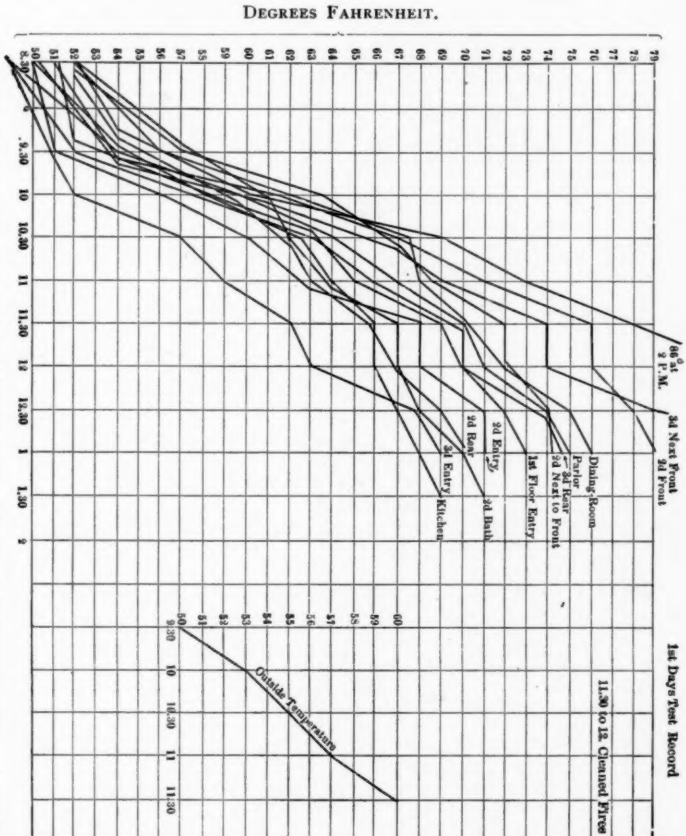
Thomas Box says, in his "Practical Treatise on Heat," page 13, 3d edition, "Ice in melting to a liquid state absorbs 142.4 heat units per pound of ice. The increase in heat, if heat were not absorbed in melting the ice, would be 281 degrees per pound of ice."

The importance of noting these facts in a heating code is very apparent, otherwise the code might be used improperly and would seem to give results not justified in practice.

The last author quoted also says, "It takes 8 times as much

heat to raise a pound of water one degree as is required to raise a pound of cast iron one degree."

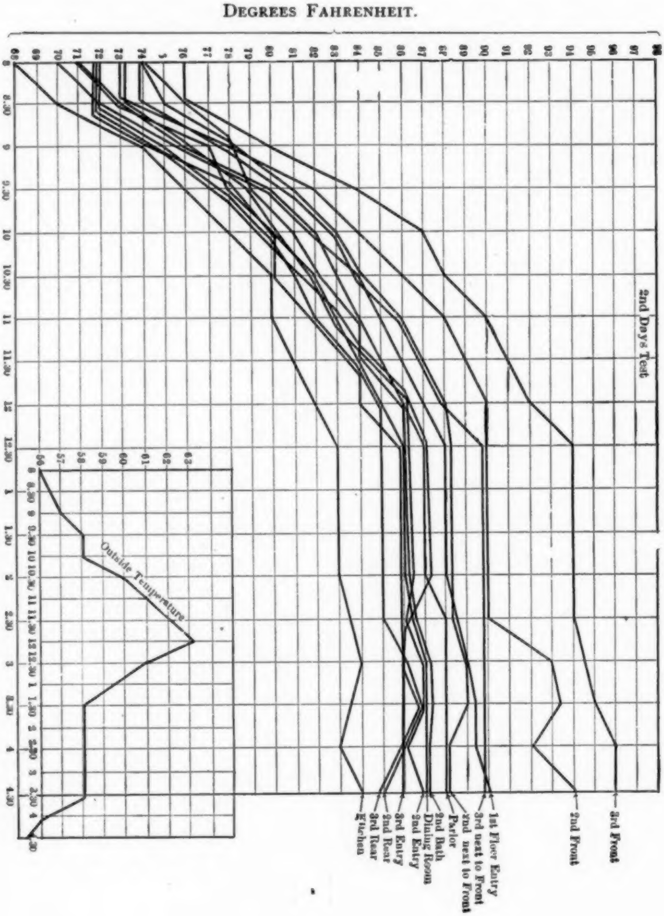
The readings were taken for private use only; but as they contain matter of general interest to our members it was



A TIME LIMIT AND DRY WALLS NECESSARY IN TESTING A HEATING PLANT. PLATE 2.

thought best to give them to the Society, imperfect as they are. On the chart it will be noticed that there is a general increase in the temperature of the rooms of about 17 degrees between the first and the second days' readings. This fact indicates that the time given to the first day's test under the conditions

mentioned is not sufficient to give a true record of the power of the plant here tested and under the conditions we here find, which are somewhat unusual in that the walls were very cold



A TIME LIMIT AND DRY WALLS NECESSARY IN TESTING A HEATING PLANT.—PLATE 3.

and also very damp, yet these conditions may be met in making tests and our proposed code should notice them and make due allowance for such conditions; the more conditions our code covers the more useful will be the code to ourselves and to all heating engineers.

We can with benefit to ourselves also consider the difference in temperature in rooms heated when furnished and when the same rooms are unfurnished. Window curtains and draperies in a furnished house may well be considered in our code. If the window glass is so placed behind draperies that the air of a room cannot freely flow along the surface of the glass, it is evident that the cooling effect of the glass upon the air of such a room is less than where the glass is freely exposed to air currents. We might be able to say, approximately, after a few tests, just what percentage to allow for furnished rooms when the test is made in rooms that are bare, but the actual requirement of the temperatures guaranteed is to be in rooms furnished.

The facts here noted would appear to justify the belief that our Heating Code should take into consideration the time of duration of tests, under varying conditions, also the dryness or dampness of walls, whether walls have been frozen, whether rooms are bare or furnished, and other conditions affecting results.

DISCUSSION.

Mr. Wolfe: Mr. Gormly, in your final tests or in the general tests was there any particular attention paid to the matter of ventilation or the removal of the air from the room?

Mr. Gormly: No, sir, there was not.

Mr. Wolfe: That makes, you know, all the difference in the world, because nothing will absorb heat better than water. We know in the old practice of drying out buildings that they shut a building up tight and put an old cylinder stove in and run it all day and it looks pretty good; let the fire go out at night and in the morning the windows will be covered with ice or water as the case may be, and it takes an indefinite time to dry it out. But if more fresh air were admitted and allowed to pass away, naturally it would have carried off the moisture with it and it would have dried very quickly. I think that should be taken into consideration also on the test question.

Mr. Kent: I would like to ask Mr. Gormly what time limit he would specify and what test for the walls being dry he

would apply,—what suggestion he has to make to the Committee on Code.

Mr. Gormly: Thomas Box, the heating engineer, says, "it takes eight days to warm a building unformly after the fire is started." I think, probably, in the majority of buildings, it would not require so much time; but, I should think that at least three days would be necessary in the average building, to make tests. My test for the dryness of the walls would be this: some tests should be made to determine the quantity of the moisture in the air of the room. If the walls are wet there will be a certain amount of moisture liberated which will show in the air of the room.

Mr. Snyder: Mr. President, I think that this paper is of very great importance, but that its full value cannot be developed without taking the character of a building into consideration. Discussing it from the standpoint of a fireproof structure, which, we will say, requires eight, nine or ten months for its construction, we have a type which will absorb and hold a vast amount of moisture. In our New York public school buildings, the walls are very thick and laid up with cement. The terra cotta floor arches are covered with three to six inches of cinder concrete, into which the sleepers are bedded. The partitions are of porous terra cotta, all of which, it will be observed, absorb and hold the moisture incident to construction. Our experience has been that in taking a school building which has been completed so as to enable its being opened for school sessions in September, which would, to the casual observer, indicate that having had the advantage of the heat of the summer the structure must be thoroughly dry, it requires more coal to heat it, say in October or November when steady heat is first required, than it does during the colder months of December or January following, notwithstanding the fact that the blowers were being run, thus insuring a constant change of air.

We have reached the conclusion that this difference in coal consumption was due to the presence of moisture in the floors and walls of the building. Personally, I attach so much importance to Mr. Gormly's paper, that at the January meeting I hope to give you some definite information on these very same lines, as we have several fireproof buildings now under

construction, which will be completed by September, and will enable us to make a practically continuous test.

Mr. Kent: I hope Mr. Snyder will give us records of coal consumption on the different days. That is the most important, really.

Mr. Snyder: I have prepared for the use of our office a four-page testing sheet, which, when filled out, will give a complete record of each plant tested.

Mr. Kent: With regard to the general specification of the capacity of a heating plant, the capacity of a heating plant depends on the coal burning capacity of it. No heating plant will be successful if it does not burn enough coal, and very often the coal capacity is limited by the draft. The heating apparatus may be entirely right as regards extent of heating surface, size of pipes and everything else, and will fail simply because of contraction in the chimney or contraction in the flue, so that the coal burning capacity of a plant is really the first important thing that we have to consider.

Mr. Payne: I would like to ask Mr. Gormly if,after this test in which the apparatus failed to get up pressure while the walls were damp, they were successful in getting the pressure after the walls were dry.

Mr. Gormly: The test was not continued except for two days, and the walls were not dried in two days. Mr. Snyder calls my attention to the fact that it might be well to state that this building, after being occupied by the parties living in it, has been giving entire satisfaction. Although there has been considerable cloudy, cold weather, it seems to be heating very well; but we have made no test of it and cannot speak authoritatively as to what it is doing excepting that it appears to give entire satisfaction. There are no complaints from those occupying the building. It has run successfully for two winters.

Mr. Payne: If it is possible, it might be well to give the proportion of the boiler in reference to the amount of radiation, and to the cubical contents. It might be a guide also, because there might be some cases where we might be called upon to put in an apparatus that would carry a pressure under those adverse circumstances.

Mr. Gormly: The building is rated one square foot of radia-

tion to 49 cubic feet of space, and the heater is rated to carry 500 square feet of radiation. There are 400 square feet of radiation on the heater, including the mains, so that the heater would seem to have a fair margin of power over and above the load it is carrying.

Mr. Payne: What was the grate area?

Mr. Gormly: It was 25 inches in diameter—a round fire.

Mr. Broomell: Speaking from the standpoint of a contractor I have had some fifteen years' experience in contracting, and our greatest difficulty has been, in carrying out any guarantee, to get proper attention to the heating plant. Continuous pressure is what is required to get good results. That is the hardest thing we have to get and it is especially hard to get in a church. In a large building which required several days to get heated it is so difficult to get a janitor to fire up in ample time to heat the building. In making any arrangement for a test, we ought to lay a good deal of stress on the time that the fire must be kept up. I have had a good deal of experience in heating from street systems, underground systems where the steam is always there, and I know for a fact that we can safely put in 30 to 40 per cent. less radiation on a street system than we can when we put in a boiler. I attribute that simply to the fact that it is always on hand. There is never any let up in the heat night or day. The house is just as warm in the morning as at night, and it is very strong evidence that we do not get the continuous pressure or the continuous attention that we should in a house that is heated with a boiler.

To do heating contractors the most good, rules ought to be laid down so that a contractor can go to his customer and show some authority for asking a test to run in a certain length of time. The owner will simply say that such a test is unreasonable without some good authority to back up the contractor. I think this test should take in not only the first test but it ought to include some formula or rules for running through the winter. If made up in the shape of an attractive little pamphlet, it would be not only advantageous to the owner, the contractor and the architect, but would be interesting, and the owner would feel that he was in the hands of somebody who knew how to to take care of him.

Mr. Sardou: It seems to me that the real issue brought out

by Mr. Gormly is the duration of test. That seems to be the basis of the whole argument. Now I do not think sufficient importance is attached to this question by heating engineers and contractors in general. My remarks are backed up by the fact that recently a standard of heating was established for the city of Baltimore which incorporated in the specifications a clause that called for a continuous running test of 144 hours. This was strenuously objected to by a majority of heating engineers and contractors in and about the city of Baltimore who wished to bid upon the specification. Now there seems to be no reason why these tests should not be made of long duration. There seems to be no reason why the aim of every heating engineer and contractor should not be along the lines of incorporating or getting incorporated in the specification a test of long duration. Then every contractor may calculate upon the cost of making that test, and he will get justice, and the owner or person buying the plant will get justice at the same time.

Mr. Wilson: I think the conditions mentioned by Mr. Gormly are the same as are met with in drying room work, namely, a temperature to absorb the moisture and an air outtake large enough to carry the moisture away in a given space of time. In a case like Mr. Gormly's, when the plant is used only for heating, it would be practically impossible to make a definite formula. Mr. Sardou says the test was a long one; but a continuous test, covering a period of time sufficient to eliminate the conditions set forth, is the only reliable one.

Mr. Wolfe: To go back to the old hobby of the Massachusetts requirements, they take care of that in a way. The contractors there guarantee to heat a building 70 degrees in certain weather, say zero weather. Now it is clearly up to the contractor whenever in his judgment the building is fit to try, and a 24-hour test or a 12-hour test, even when the building is dry at a certain outside temperature, would ordinarily seem to fit the occasion. Certainly the contractor would not try to heat a building with wet walls. He has a right to insist that the building shall be in proper condition, or as we used to say in a contract, "the building being of good construction, properly fitted," and so forth about the window frames.

Mr. Payne: In Mr. Wolfe's former remarks, he advised that

the air be removed and seemed to intimate that it would make quite a difference in the recording of pressure on the boiler. Did I understand that correctly?

Mr. Wolfe: I did not refer to the boiler; I referred to the drying of the building. You cannot dry a building in a million years if you keep it air-tight, no matter how hot you heat it. You can dry it apparently but immediately that it is closed again the moisture is there. The air acts simply as a sponge. Air at 59 degrees, we know, will carry one eightieth of its weight in water and that is all it will carry. Every 27 degrees that you raise that air it doubles its water carrying power. Consequently, the temperature of the air determines how much moisture it will hold and carry away. The objective point being to take the moisture from the building, why of course immediately that you have saturated the air to the point of complete saturation, take it away and put in more fresh air, so without the means of removing the air as it becomes saturated you cannot dry out a building in any time, I do not care how long, if it is air-tight. Possibly in time it may go through the walls.

Mr. Payne: In this instance, we have, first of all, the apparatus carrying 10 pounds of steam with the most perfect ventilation, that is, an almost free circulation of air through the building, there being no plaster on the walls, and cotton cloth in the windows instead of glass. Now what would have been the result if after the building had been completed the same amount of air at the same temperature was caused to pass through the building—could the boiler under these conditions maintain ten pounds of steam the same as before the plaster was put on the wall and when cotton cloth was in the windows instead of glass? We see here that they were able to maintain 10 pounds of steam without any plaster on the walls, but with cotton cloth in the windows instead of glass. Then they put plaster on the walls and glass in the windows and they could not get any pressure on the boiler.

Mr. Wolfe: I look at it this way—that the lack of pressure on the boiler shows that the heat is passing away faster than it is generated. If plaster is in the walls you are trying to evaporate tons and tons of moisture in the building and that takes the heat. In both cases the heat is either leaking

away or being absorbed by water faster than the boiler makes it.

Mr. Sardou: Perhaps I can enlighten the members on this subject. I made some tests a year ago near Philadelphia. Some of the houses were unplastered, and with cotton in the windows. Some of the houses were plastered, with cotton in the windows, and some of the houses were plastered, with the sash in position. I saw no material difference from the effect produced at Mr. Gormly's test in any of the houses—none whatever, whether there was cotton in the windows or whether the sash was in position. The test that Mr. Gormly made was borne out by my observation of what had been accomplished in six or seven houses in the course of construction at that time. I was running the heating plant for the purpose of drying the plaster, and at no time during that period was I able to raise any steam upon the boilers. The plants were designed upon an exposed wall and glass surface basis, using Professor Carpenter's rule. After the houses had been occupied for possibly a month during the winter, they came up and ran ahead of the tests, equivalent to 70 degrees in zero weather, although we had no zero weather at that time. I applied Professor Carpenter's rule to the heating plant and found that they ran above what they were installed for. During the plastering period I was unable to get any pressure on the boilers whatever. All the radiation was placed in the buildings and the sash and glass were more than reasonably tight. The houses were well built, built on day's labor, and of the very best material, most of them stone first story, and shingle from that up.

Mr. Trachsel: I think this is a very valuable paper for this reason: It sets our minds to thinking over these matters and make us consider what is detrimental to a heating plant, but yet it wants to go further. I would like to know the amount of glass surface, wall surface, cubic contents and the exposure. I would also like to know the class of boiler so that I can ascertain the square feet of grate and also the boiler surface. Then I can compute just exactly the comparison. Where the walls were newly plastered—I think it states here that the windows were quickly covered with ice—you had to do the work over again, evaporate the moisture from the plaster and then take it up again.

Mr. Wilson: I think the member wishes to know why the consumption of steam was so excessive. As this plant was installed for heating only, the elimination of the moisture from the walls and the out-take of the same, was extra work. The extra amount of steam required to do this work prevented the accumulation of the pressure at the boiler. The rule usually applied to drying room work, viz., temperature of air sufficient to absorb amount of water per unit of time and travel of air through out-take, or vent, to carry same away, is somewhat analogous to the conditions mentioned by Mr. Gormly. It is like putting a heavy load on a man; he cannot travel as fast as if he had no load.

Mr. Kent: I had an experience a couple of years ago which confirms Mr. Sardou's statement about the difficulty of heating up a building when it is new and when it is cold. A new steam heating plant had been put in a church and at the same time in a large Sunday-school room. One Saturday afternoon the thermometer got down to about zero out of doors and the thermometer inside of the Sunday-school room was below the freezing point, and the sexton undertook to try and heat the building, under those conditions, with the new plant. After working several hours, he was not able to get over half a pound of steam in the boiler, and the effect of the steam heating was such that the steam passing out of the boiler into a long line of coils was condensed entirely to water, and before it got to the other end it was ice and burst a heating coil—actually making ice in the heating coil. They were only small cracks and did not do any harm. We kept up the work all night long and at the time of church service we were able to get between 55 and 60 degrees. That was all that could be done after 18 hours of firing. There was nothing to account for it but the cold condition of the walls and the impossibility of burning coal fast enough. The limit in this case was the chimney. The chimney was taken down and enlarged and the steam pipes felted. After that there was no trouble in keeping that church and Sunday-school as warm as you pleased. So this time limit seems to be very necessary. In that case after 18 hours of firing all they could do would not heat the building. It shows, as I said, that the important point is coal capacity. If you don't burn enough coal you will not be able to get the heat.

Mr. Sardou: It seems to me that the real issue brought out by Mr. Gormly is a question of time limit and the condition under which the building should be tested. That is the point that you wish to bring out—that the contractor should not be compelled to make a test while the building is unoccupied, while the walls are green, when the sash, doors, and everything of the kind are not in. That seems to be the real issue, and I believe that if we could incorporate something in our handbooks or in our code of rules and regulations by which a contractor could not be compelled under any circumstances or would not be requested to make a test while the house was in that condition, it would be a good thing. I intended to say that he would not be compelled to wait for his money, but that is something to be regulated by the contractor himself. These are the points—the time that the building shall be occupied before the test, and that the test shall be a long one. The limit set in Baltimore for the schools, of 144 hours under these fan systems, I consider a very short limit, but as a longer test would not be permitted that was accepted.

Mr. Addams: It seems to me that a good deal of fuss is being made about fresh plastered walls. I have heated rooms where they had tanks of water and had no trouble in raising the temperature. I like Mr. Kent's way of putting it. Mr. Kent says "cold walls." I think that makes all the difference in the world. The saturation of the walls with moisture is not as hard to contend with as the temperature that is in them. It certainly ought not require so very much more heat to warm moist walls than it requires to raise that same amount of water to a corresponding temperature. I think it is the temperature in the walls that we have to contend with, whether it exists in water, brick, stone or plaster.

Mr. Payne: I think if the gentleman stops to consider a minute he will not agree with himself. He says it is the temperature of the wall you have to consider most and not the moisture. Take for instance a line of steam pipe uncovered, passing through soil at a temperature of zero, but the soil dry, and compare with a line of steam pipe passing through moist soil at a temperature of zero, the condensation in the latter case will be much greater than the former. Therefore I think it has a very

great bearing on the subject, whether the walls are merely cold or cold and moist.

An instance of similar nature was brought to my notice lately. A reputable concern engaged in the heating business recently installed a steam boiler in a residence in course of construction, and the first test was made when the walls were covered with wet plaster. It was found that the boiler could not maintain pressure and it was therefore condemned. The conditions were just the same as in Mr. Gormly's case. The manufacturers of the boiler, who were somewhat new in the business, agreed to furnish additional sections free of charge so as to enable the boiler to maintain steam pressure under these adverse conditions. In another case I know of, there was a boiler of the same design installed in a large building under similar conditions of wet plaster, etc., and there was not the slightest difficulty experienced in maintaining 15 pounds of steam at any time. In the first instance, there was a chimney about 35 ft. high and 8 x 12 ins. inside, in the latter case there was a chimney 50 ft. high and about 24 x 24 ins. inside; this I think seems to agree with Mr. Kent's contention that it is a matter of fuel consumption.

Mr. Sardou: I should like to hear some further remarks from Mr. Gormly on this question, and I would like to have him incorporate that chimney question which seems to have been brought out as a rather prominent one, and also the question of tests as brought out by myself.

Mr. Kent: In regard to this test specification, should the code read that a certain heating plant will heat a building to 70 degrees when the temperature is zero outside or that it will maintain the temperature at 70 degrees when it is zero outside? You take a cold building and ask the heating plant to heat that building to 70 degrees, it is one thing. But if you have a building which by previous heating has been gotten up to 70 degrees and that heating plant is to maintain it at 70 degrees, that is an entirely different proposition. It may take two or three times as much coal to get a building warmed up in 24 hours as it will the next 24 hours to keep it at that temperature. So I think some statement of the kind should be put in the code, that the specification should not ask that a plant be required to heat a building to 70 degrees if the build-

ing is cold when you start, unless you give it about 144 hours, as Mr. Sardou has said. I would like to ask Mr. Sardou, in regard to the 144-hour test, whether it was intended that at the end of that time the temperature should be up to 70 or that it should be up to 70 during the whole 144 hours.

Mr. Sardou: It is my impression, although the specifications are not as clear to me as I should like, that it was optional, or that it was mutually agreed upon between the inspector of buildings and the contractor as to when that test should be made. That test may be made at any period, so far as the contractor is concerned, covering 3 years. It may not be made the first winter or the second winter, but he may like to make it the third winter. As to the period of time during the running of the plant as to when this 144-hour test shall take place, that is not stated in the specifications. Therefore the contractor could elect to make it in March, say, after the plant had been run three or four months.

Mr. Oldacre: As I understand, a heating plant is for the purpose of taking care of a building in its completed state and for ordinary uses, not particularly for the purpose of drying out a building, which is rather an incidental question and with your permission I would like to ask Mr. Wolfe a few questions. There are three questions, each one following and having a direct bearing on the one preceding it. Does not Mr. Gormly's test show that such differences are due to the relative humidity of the inside air? The second question is, if so, has not the relative humidity a direct bearing on the temperature resulting, and if this is true could not a separate humidity at a given temperature be set as a condition of test?

Mr. Wolfe: I do not think that the condition of humidity, that is, a set figure of humidity, which is the gist of all of Mr. Oldacre's three questions, could be made that would be satisfactory either to the owner or the contractor, for the reason that you don't know how much water there is in a wall or how much water the heat will bring out. I am speaking now of a wet building. After it is properly dried, why that is another question in the line of heating, but how much water must be carried away to be put in the form of a contract clause, why you must know how many tons of water have entered into the construction of that building, and that is, of course, an impossible

thing to find out. Your heat will draw water from the walls, condense it, and if it is passed away you will dry your buildings very much quicker than you will if it is left there, because it will take an indefinite time to dry it if it is confined.

Mr. Broomell: Mr. President, it seems to me that this discussion appears to be going toward the idea that we are putting in heating apparatus to dry the buildings, dry the plaster. Now, I do not think that is what we put them in for. The test of course was of a plastered building and is very interesting; but that is not what we want to incorporate in the specifications. I dont see why that should enter into the discussion. What we want is a specification that will fill the bill after the house is ready to live in, not when it is being built. We know that we cannot dry the plaster and heat the house to 70 degrees with a plant that is suitable to heat it when it is finished. I dont think that ought to be incorporated in the specifications of the test at all. I do not see why it has any bearing on the subject.

The President: Gentlemen, we have with us a gentleman from Boston. He has been in business a great many years, and I would like, if possible, to hear a few words from Mr. Kendricken, of Boston.

Mr. Kendricken: Mr. President and gentlemen, I have been listening here with interest to the discussion. Reading once about the early days of the looms—some worked and some did not work. One old fellow's loom always worked. His cloth and everything came out without any broken threads or any fissures to show imperfect work. It was necessary to find out how he fixed his loom and they gave him two quarts of beer a day if he would tell. It was agreed to. He said, "chalk your bobbins, man—chalk your bobbins." That is the secret of the easy-moving bobbin—he chalked it. Now, the boiler that my friend Gormly speaks of, down my way would not hold water. We never run so close to the wind. He fails to state grate area, but I can see from the rating of the boiler, 500 square feet, about what that boiler would be. We would not dare to put it in. We believe in this continuous heating. You can reduce your radiating surface when you increase your grate. Get a good grate, a good-sized boiler, and you will have an easy matter to get up steam, an easy matter to get your water into cir-

culation and hold it, hold it up to 190, 210 if there is any question about it. As regards drying buildings down our way, we put a clause in, temporary radiators $2.50 apiece; in one case they had to pay me $1,200 for extra radiating surface to help to dry the plaster. In addition to that, the contractor had twenty salamanders and yet it was with great difficulty that that building was dried. One man in our business, a contractor, has been 15 months trying to dry a building. Fifty years next July, if I live, I shall have been steam heating, trying to dry buildings. To-day it is not so easy to dry buildings as it used to be, for the reason that you build high buildings, you have massive thick walls to sustain great weight. They are set in moisture and you would think that under that great weight and great pressure the moisture would be forced out like the juice of a lemon in a squeezer. But that is not so. The inclination is to get moisture in. It is like your clay hill. Take a clay hill 200 or 300 feet high with water trickling down the sides. To undertake to dig that hill away with a pick and get it away would be impossible. Now, these big buildings I find are very hard to dry. Near the sea they are especially hard to dry. Inland it is somewhat different. A friend of mine built a large building. He was getting old, and he and his wife wanted a large building before they died—the old man's folly. I got the contract. I understood he was going to spend a great deal of money on the building for embellishment; for instance, such as painting on the walls. I took him to one side and told him that if he was going to spend any money painting on those walls, he would lose it all; the painting could not possibly last over 15 to 18 months on account of the condensation of air upon those walls, and the action of the trickling water on the walls. The result of it was that the walls were cut down, opened up and put into shape to receive his paintings, so that the walls would not "sweat" as we call it, Now, you know to-day that many buildings are being built without any plaster whatever—faced brick inside, and everything in elegant form, beautiful work and masonry. Now, you contract to heat that building and the result of it would be that unless you made provision for an extraordinary amount of heating surface, it would be one of the coldest buildings on earth. When we are invited down my way to bid on a heavy

stone building, we carefully look at the plans, and if we find that they are going to build a wooden building inside of it, we have, in that case, a soft snap; we can heat the building without any trouble; but if they put wire lining on the other building, we find ourselves in petty bad shape unless we are very careful. So, as you go from one locality to another, things differ. Zero is our point. No man asks us down my way to undertake to do anything unusual in a building until it is completed. Thirty-five days after it is completed we get our final payment, if we can.

Now, I am talking about direct radiation all this time. When you put a fan in, and you put it in right, we don't care much whether the walls are thick or thin, or whether those walls are built with air spaces, which they consider to be rather an expensive affair, but a mighty good thing for buildings, especially school buildings. You take a church, a large church, not very heavy walls, and you start to heat the church with a blower and you don't have any trouble with it. You put in direct radiation, and you get 40 or 50 candles and put them around the outer walls and see the flapping due to air currents. If the candles are held up in the centre aisle pretty well, they will all blow unusually high from the floor, showing the currents in the church that you are not able to control—the chilling influence of the outer heavy wall—nothing on it but damp plastering. Now, that is where it is zero outside. I don't say anything about below zero, because it is hardly fair. We have sometimes a little below zero. Five degrees is about the limit. Eight or ten miles from Boston it is astonishing how the thermometer drops. They get it 20 degrees when we only have it 3 in the city of Boston, so that when we are figuring at those remote places we have to look out and put in an additional amount of surface, but there is nothing like having a boiler with a good grate in it, liberal sized pipe for what they have got to do, and a fair amount of radiating surface, and I will venture to say we will all get our money in 35 days if the man has got it in his purse. (Applause).

CII.

TOPICAL DISCUSSIONS.

TOPIC NO. 1.

The Tenth Anniversary Meeting, 1904; Suggestions for Making It a Very Notable Occasion.

Is there any gentleman here that can give us any suggestions as to what is for the best interests of the Society at our annual meeting in 1904? I would like to hear Mr. Chew, the Chairman of the Committee.

Mr. Chew: Mr. President and gentlemen, I rather think that the President has made an improper selection in the chairman. Mr. Harvey is entitled to the honor. With him the idea originated, but it was accepted by the Society as an excellent one and a committee for the work has been appointed. The committee was not appointed until late and there has been no meeting of the members. I have talked with a number of them, however, and the feeling has been that they would like to have suggestions from the members, and while some suggestions have come to me I should be glad before presenting them to the Society if the members will make suggestions, so that what I might say will not cut off others. Now, Mr. Harvey has some suggestions, and before I say anything further I should be glad to have Mr. Harvey take the topic up and speak to us upon it.

Mr. Harvey: I think that the chairman of the committee is is wrong in saying that the President made a mistake in placing him as chairman of the committee, because he did not make a mistake. He is a much younger man and can get around many more places than an older one. The appointment is well made. I would suggest that the President add two or three other members to that committee. The subject is of sufficient importance, and for the interests of this Society we cannot make too much of it. Whatever we do in that line

ought to be well done, and this meeting here comes at a very opportune time to get many suggestions from the different members, so that the committee can go over those suggestions and embody them in their report. Several suggestions have already come. In the meantime, it would be well to look forward to the point of advertising this tenth anniversary, not only in this country but all over Europe. If there is anything in a society that can do good, it ought to give the same results in other countries as well as in the United States. If it can be advertised in such a manner, it will be of more benefit to the Society than our present way. This is by way of suggestion only. It might not be a bad plan to advertise it in such a way that in the course of a year or so as many members of this association as could find it convenient could hold a summer meeting perhaps in Germany or some place on the other side of the water—possibly by meeting with people over there we would get as much good as we gave. Other suggestions on this subject may come later on.

Mr. Wolfe: To substantiate Mr. Harvey's remarks, every year there is published in Germany a book containing the names of members of the recognized societies of the world, and in the publication of 1899 every member of the American Society of Heating and Ventilating Engineers is named. We are all recognized over there, so that is a good deal in less than ten years. If we have gone as far as that in five years to gain the recognition of the world, that is surely something. I can cay from the little experience I have had that the American Society of Heating and Ventilating Engineers is looked up to by the engineers abroad to a very much greater extent than we ever expected to be looked up to. From the discussions that I have heard about it in the French societies and the English and some of the German, they seem to take us as a pattern. I know one of the best engineers in Europe, who came to me and said, "Can you tell me anything about this vacuum system of heating?" I thought I could tell a little something about it, but I said I think I could give you a better idea from one of the books here in the exhibits of the American Society of Heating and Ventilating Engineers, and I took down the copy that contained the discussion that Mr. Bolton gave us. I let him glance through that, and he

said, "I should like very much to take this home." I said, "I cannot let you have it." At last I said to him, "Well, I will loan you this for a week. You are interested in this subject; I will loan you this copy for a week if you will give me your word of honor you will send it back." In a week he wrote me saying, "I studied that subject all that I cared to, but I do not want to return the book. I enclose check for a guinea, and if that is not enough I will send you some more. Of course, if you cannot get along without it, I will send you back your book, but I want it." And I let him have it. I think the treasurer got the money. But really you are thought to be the leaders of the world in the line of heating and ventilation over there.

Mr. Harvey: The thought was suggested to me that several years ago there was a meeting of civil engineers of an American Society, met in Glasgow, Scotland, and I happened to be at a banquet given by the council of Glasgow, and the advertising that that Society got was worth all it cost. It is a good thing.

Mr. Kent: In regard to this convention of 1904, we are not well enough advertised in this country. I think the best way to advertise ourselves in this country is to prepare to have a meeting at the world's fair in St. Louis, in 1904. At the Chicago World's Fair in 1893, there was an engineering congress composed of the different branches of engineering, represented by delegates from all over Europe, and that congress was an exceedingly successful one, attended by large audiences and in a great many different sections. But the Society of Heating and Ventilating Engineers was not then known. There was no discussion, as far as I know, in that congress, relative to heating and ventilation. In St. Louis we can have an engineering congress of all the different branches of engineering, including the Society of Heating and Ventilating Engineers, and our programme can be printed a long time in advance and circulated in Europe. We can have the biggest congress of heating and ventilating engineers ever gotten together. I make that as a suggestion.

Mr. Harvey: A very good suggestion.

Mr. Wolfe: I understand our jubilee meeting is to be the annual meeting.

The President: Yes, sir.

Mr. Wolfe: Does not our Constitution require that to be held in New York?

Mr. Chew: It is proposed to extend the prestige of the Society by having the extra meeting in St. Louis.

Mr. Kent: The summer meeting, and it shall be an international meeting of Heating and Ventilating Engineers.

Mr. Chew: The committee will be glad to receive your suggestions. That of Mr. Harvey is a good one, that one of the papers to be prepared for the 1904 meeting be a history of what the Society has done in the past ten years. I have made a note of that, and intend to ask Stewart A. Jellett, than whom no one knows more clearly the objects of this Society and what it has accomplished, to prepare such a paper. Some of our members here may not know the extent to which the published proceedings of our Society are referred to in the different colleges which have an engineering course, or the number of libraries where scientific works are gathered, on whose shelves our Proceedings are to be found, so that a paper along these lines would surely be an interesting one to present at the meeting in 1904. It has been suggested that these and other papers be prepared in advance, not late, like the papers that have come here in galley proofs. They should be received six weeks in advance, so that they can be sent to the members and digested. Delay in sending out the papers is one of the troubles that this Society has always experienced, and which has tended to reduce its membership. I am satisfied that our membership would be much larger and that much more interest would be taken in the meetings if the papers were received in time to be printed and sent to the members before the meetings.

Now, to come to the suggestions that the committee have received: Mr. Seward of New York is the only member of the committee I have had a talk with, although Messrs. Stangland and Barron are in New York also. Mr. Seward says that the opportunity for advertising the Society should not be lost. The Society has already risen to a place where it ought to be brought to the attention of men who will take a deep interest in its work when they know about it, and the tenth anniversary will afford an excellent opportunity to bring it to the attention of those men. Mr. Seward's idea is—to make it

specific—to get up a four-page letter-sheet. The first page would have at the top, "The American Society of Heating and Ventilating Engineers," and then in big type, "Tenth Anniversary Meeting, 1904," and if we decide that it is advisable to have the summer meeting in St. Louis, it would be well to put that on also. This first page is blank for correspondence. Then we turn over to the next page, and with "The American Society of Heating and Ventilating Engineers" at the top, explain its objects, aims, and what it has acomplished. Here would be given to a man who knew there was such a society, but who possessed little information as to its scope and character, a good deal of information about the Society. Enough room would be left to print the names of the entire membership, and I think some of the lesser lights, like myself, would not be envious if some of the achievements of our more prominent members were put down. This letter-head should be sent to every member of the Society. Every member knows some man who ought to be a member. We are not only after the man who is a graduate of some college, or who has done some big work. If he is an ambitious young man of the right sort and character, he will do. We do not want a man who is in the habit of painting the town red. We will wait until he settles down. When this suggested stationery is received by the members they will be sufficiently discreet to use it for correspondence with the right people. This is Mr. Seward's idea, if I understand it rightly. If the 200 members of our society use stationery of that character it will certainly bring it prominently before a great many men who are not now members, and who will see that it is a society worthy of their support by membership.

My ideas have been on an entirely different line, and there are two of them. The first is suggested by the fact that the Master Steam Fitters' Association has gained very substantial prestige from the circulation of the "Standard Flange Schedule." A few years have elapsed since that was put out, and now the frequent use of high pressure has made the "Standard Flange Schedule" subject to change and improvement. I want to preface one of my ideas with these facts, so that the idea that I want to present will not be subjected to the criticism that we are not setting up any standards because they

will not be perfect. We do not care if they are not perfect at the start. We shall be glad to improve. The society can give to an immense number of people a little handbook for this meeting of 1904, saying the Committee on Standards has advised the following suggestions: For a two-pipe steam system, the size of the main could be determined for a certain amount of radiation by this formula. Then give a little table. Turn over to hot water and do the same thing; and, as the hot-air furnace men are coming to the front in this society, I think a page should be devoted to hot-air furnaces. I think we can depend upon Mr. Oldacre and Mr. Switzer to fill out that page. Now, a small handbook on the society given out at that particular January meeting and then circulated broadcast, notwithstanding that manufacturers put in the back of their catalogues that a 1-inch pipe ought to have a given size of return pipe to be effective, would do a great good, and such a handbook would prove one way of advertising our society.

We ought to have at the 1904 meeting papers on work that has never come up in our society. The ventilation of ships of all sorts is interesting to a limited number of people. Consequently it belongs in the 1904 meeting. Transports have carried no end of soldiers to Manila, and their heating and ventilating systems have not been described. There were special ventilating systems in these transports. I have talked with a member who says he has sold to the Government apparatus of various character, and I gather from his talk that there is something rather unique in the method of heating those transports. The committee will be grateful if he will find some way to prepare a paper along those lines. I want to see special papers of unusual interest presented. I do not care whether the paper is on a fan system, or a vacuum system, or some simpler system, so long as it is of unusual interest.

This is the line on which my mind has run for making that meeting a success, and you can see that there is a lot of work in it for somebody. I have not as much time to give to it as it may need. Consequently, the members of the society must lend their assistance promptly, or possibly the effort will fall flat and we will have a failure, not due to lack of interest on the part of the committee, but to lack of material, which can only be furnished by the members.

Mr. Wolfe: I do not wish to be understood that I contemplate the holding of our meeting abroad or anything of that kind. I think the United States is good enough for us just now. I think the line of work as outlined here is also all right, but the main object of our 1904 meeting, I understand, is to make it of general interest to all who have anything to do with heating and ventilation, to increase our membership and to bring with us as many as we can that are in our work, either directly or semi-directly.

Mr. Switzer: The point mentioned by Mr. Wolfe is a very important one. Regarding the increase of membership, I think that should be a very important factor in preparing the prospectus for our tenth anniversary, and that the members themselves should be largely instrumental in assisting the committee. A committee of ten or a dozen members can not accomplish what is desired without the coöperation of the society. This prospectus, in order to draw out an expression, should be prepared along the lines discussed and a number of application blanks forwarded to the members to circulate with the prospectus, and each member can make it a special obligation upon himself to secure additional members. The success of the Society will depend upon the increase of membership and the increase of revenue. Increase of revenue is necessary in order that the Society may have funds, with which to publish its Proceedings and attract to these meetings more men of experience in the heating trades. As our good friend from Boston stated a moment ago, we do things differently down our way. It has been my observation, that in many other sections of the country, the same expression prevails, that your meetings and discussions are all right in New York. The Heating and Ventilating Engineers are doing good work in Philadelphia, Baltimore and Boston, but when you come to the northwest, why, your rules don't apply at all. In the Rocky Mountain regions, and on the Pacific coast, they have different methods, and there are some bright engineers in that section of the country who should be members of this society. They say we are too far away. If the society could be brought to the point that these engineers could be attracted to become members, we could get some desirable data from them, from their correspondence, and in the discussions, as Mr. Chew has

said, provided the papers are distributed far in advance. How often it is that the papers are handed to us when we arrive at the meetings. Some persons have said, "Well, you get together and you discuss random thoughts. The best results do not come from those random thoughts." There is greater interest being taken by the society, and the thought occurs to me as a member of the committee to get an expression from the members in preparing this prospectus. If the members of the society would be especially interested to see that these applications get into the hands of engineers in the other sections of the country and in Europe as well it would be very beneficial, and the tenth anniversary could be made more than we hope and anticipate for in the way of an increase of membership as well as larger attendance at the various meetings of the society.

Mr. Chew: It may be of some interest to the members to know that this committee is appointed to work in conjunction with the Board of Governors, so that in what we may do we must have their sanction, and possibly we may need some money to do some of these things later on. We will need some money, I think, to carry through some of the things that have been suggested, and the idea of inviting the foreign trades to come here to either our annual meeting or semi-annual meeting strikes me as a good one. It simply means to get a list of the membership of the British Institution of Heating and Ventilating Engineers and the German Heating and Ventilating Trades, which should not be difficult, as we have Americans that are members of our society, who are now located abroad, as well as the foreign members of our society and the gentlemen Mr. Wolfe speaks of. There are two past presidents of the British Institution who are members of our society. One had the honor of being on our Board of Governors in the days gone by.

Mr. Wolfe: Do not forget the French Society. There is a society in Paris extensive enough to occupy a whole house and have heating apparatus as far back as it is possible to get a sample. Their exhibit in the way of the history of the art is very interesting, but they do not show that they have done much to improve it themselves.

Mr. Kent: I want to make a suggestion to the committee which I made to Mr. Chew to-day, but I might as well make it

publicly. For this tenth anniversary meeting which it is proposed we might have in St. Louis and have it an international congress of heating and ventilating engineers, we should have a series of papers by men best qualified to write papers on the several subjects. The volume of Proceedings of that meeting should be a résumé of the state of the art of heating and ventilation in the United States at the present day. One man would write on the hot-air furnace system, the best practice in that; another on the blower system; another on indirect and direct radiation; another on office buildings; another on the refrigeration of rooms, and so forth. The best practice at the present day should be described and especially put in the shape of formulae and rules wherever it can be done. Let us have a new and carefully prepared table, for instance, on the amount of heat that will be radiated from a radiator of given shape and size and type. Our literature on that subject is very confusing. I had occasion recently to look into the subject of how much heat I could expect to get out of a radiator and I found the utmost confusion in going over the figures. Mills's tables and others show a great variety of results got by different people at different times. It is time these results were compared and other experiments got together so that we could give a new table on the subject. I make that suggestion to the committee that they get papers on specified subjects relating to different branches of heating and ventilation for the Congress in 1904.

Mr. Chew: I am glad that Mr. Kent is in New York and is also a member of the Board of Governors. I shall be glad to confer with him on this subject. Mr. Kent has outlined his ideas and he can expect the demands that will be made. A much longer list of papers will have to be prepared by the membership and naturally the success of the meetings along the lines he has presented will be entirely due to our efforts. I think that a good many people put off the preparation of papers until the very last minute. Again, our members are too modest. We ought to have descriptions of some existing plants—as he says, hot-air furnace work, for instance, which is rather looked down on by some of our members, but not by me—the two-pipe steam system, etc., if you like. A record of the state of the art is a good idea. People might say you don't

want to have a description of some job that has been in the archives of the society for twenty-five years. It would be very satisfactory if you could go back and say 25 years ago they heated factories on this plan. I think if all the details are put in as they belong, it would be valuable. I would be glad if the men who are not professors and have not got any C. E. or M. E. or any kind of an E. back of their name, would give a description of the kind of work that they have done. The society is somewhat the same as our office. We have a waste paper basket. The good things we save, but the rest go there. Everything that you present to the society goes through the hands of the Board of Governors. If they do not think it is worth taking, it will be sent back, returned with courtesy. There is the safety valve between you and the public—the Board of Governors. There is no danger of any member of this society presenting a paper that will reflect to his discredit or to the society's discredit. He will probably have help in the suggestions that will come from the Board of Governors, in saying, put in that or put in this or the other. I earnestly hope that instead of being as modest as they have been in the past, they will take the suggestion home and describe some of their work. The things that have been done if carefully explained in detail are much more interesting to the men that have to do something and plan it. You members who doing the little things, tell the society about them.

Mr. Blackmore: Mr. Kent has opened up what is a very large subject. At the same time it is one that ought to be taken in hand. Our tenth anniversary ought to be celebrated in a tangible way by this organization. I would suggest that the Board of Governors should make a list of subjects that ought to be treated in several papers and have the secretary send them in circular form to the members, asking them to notify the secretary at the earliest date which one of the papers the member addressed can undertake, and if they do not volunteer, let the Board of Governors designate certain parties to prepare papers on the selected subjects.

Mr. Chew: A while ago I sent a letter to every member of the committee, saying that I hoped that previous to this meeting any suggestions they might have would be sent to the chairman, and I did not receive a single suggestion. Now, Mr.

Harvey is making two or three. If he and other members will only make them in black and white it will greatly help men who are too busy to do this work justice.

TOPIC NO. 2.

Heating Ovens, etc., with Oil in Coils.

Mr. Harvey: In regard to the heating of ovens or kilns with oil, that is, with oil used instead of water passing through coils: They heat ovens up to a temperature of 400 degrees with an open-tank system with oil. That is done, and I do not know how much higher temperature they can get. That is the way that most all of the Battle Creek food products are cooked.

The President: Has any other gentleman anything to say on this subject?

Mr. Gormly: On the line of the remarks made by Mr. Harvey about the heating of buildings with oil in the coils, that thing was carried through in the city of Philadelphia in one building and it was not a success. I believe they mixed linseed oil with vinegar and used it in the coils and ran very high temperatures, but the difficulty was there was no economy in it because they could not absorb sufficient heat from the gases and they escaped at the chimney at very high temperature because the entire plant was running at high temperature and would not absorb the heat. There being no economy in it the thing was a financial failure, although I believe that one man did make some money out of it—the man that engineered it through and sold stock; he was all right, but the rest did not gain anything but experience.

Mr. Harvey: But it is the only system that can be used still for baking that kind of goods, no matter about the economy. I was not talking about the economy.

Mr. Gormly: Yes, there may be special cases where it is all right.

TOPIC NO. 3.

The Need of a Laboratory for Technical Research in Matters Relating to Heating, Cooling and Ventilation.

Mr. Broomell: I have not had the honor of being a member of this Society very long. I do not know how rich or how poor

we are. I take it that most of us are members for possibly our own benefit. If we are rich enough it seems to me we could see the most returns for our money by making an "experimental farm," so to speak, as they have in Pennsylvania. Take New York or Philadelphia or some other large city; we could get a building and put it in the hands of a competent manager, and make it so that any inventor or manufacturer or anybody that is interested, could send new things there and have them thoroughly tested out in the most scientific manner and have all of our present methods tested out one after another, the results tabulated and published. It would be of practical benefit to every one connected with manufacturing establishments. It would seem to me that if it is at all possible we should establish an experimental plant thoroughly up to date. It would cost money, but I, for one, would be willing to stand my share of the expense. I believe it would be a paying investment for all of us.

Mr. Kent: In the *Engineering and Mining Journal*, a few months ago, there was an editorial published on the necessity of a laboratory for engineering research, and it brought to the attention of the proposed Carnegie Institution at Washington, the establishment of an experimental laboratory such as Mr. Broomell suggests—grounds to cost not less than $100,000. Such a laboratory to take hold of all sorts of engineering questions. A strong appeal was made there for such a laboratory. Professor Thurston of Cornell University, wrote in answer to the *Engineering and Mining Journal*, saying that the Committee on Engineering had been already organized, of which he is a member, and that suggestions of that kind would be gladly received. I think if any one has any chance to bring any influence on the authorities connected with the Carnegie Institution at Washington to put up a building for engineering research, which includes heating and ventilation, then we could have a series of systematic experiments carried on there under the direction possibly of our Society, which would fulfil all the demands which Mr. Broomell makes.

Mr. Blackmore: The point that Mr. Kent brought up—that Professor Thurston, of Cornell, was one of the committee to take suggestions as to the question of establishing an experimental engineering station, is one that I think we ought to

act on. We all know that the state of the art is very young. It is very much undeveloped. Notwithstanding the great development that has taken place the last 10 years in heating and ventilation, there is still a great deal to be done. When they are establishing that university at Washington for original research, I think it is a very important matter that this society should memorialize Professor Thurston. He can present the thing to the proper authorities in a strong form. Merely to write a letter from two or three of the members to him on some points, would not be nearly so strong as a proper resolution from this body memorializing him to adopt some such technical station for engineering research and for testing original new inventions.

Mr. Harvey: Mr. Kent answered that just a few moments ago by saying that a number of professors of the different colleges of that committee, requested that the money be distributed to the several colleges for the different colleges to do that experimenting, so that that would knock that whole thing all out.

Mr. Blackmore: Mr. Chairman, almost all of our large colleges now have a scientific or an engineering branch where a technical training is given. Some of them are better equipped than others. There is none of them so well equipped that they can do everything that is necessary in the way of testing various appliances used in engineering. As I understand the scope of the Carnegie plans for the university at Washington, it is wholly for original research. Therefore, something on a great deal larger scale than can be accomplished by any university ought to be adopted there. The mere fact of distributing a certain amount of money to each of the universities for enlarging their scope in that branch, would not be nearly so good as to have one thoroughly equipped laboratory for this purpose at the national capital, and while it will undoubtedly do a great deal of good to enlarge the scope of the various universities, it will not do anything like as much good as to have a national laboratory where it could be equipped away beyond what is possible with any of the universities. And I think it is quite within the scope of this society to memorialize the committee to that effect.

Mr. Harvey: I think it should be done at once, too. This

society could not do anything that would be of more lasting benefit.

Mr. Kent: I happen to have Professor Thurston's letter in my pocket, and I will read it:

A Laboratory of Engineering Research.

Sir: I have read with interest the very thoughtfully prepared article in your issue of April 5th, on Engineering Research. I am able to state that your suggestion relative to an advisory council of engineers to work with the trustees of the Carnegie Institution has been anticipated and that the executive committee has requested me to arrange for the organization of an advisory committee to consist of the following named members of the profession: Wm. H. Burr, George Gibbs, George S. Morison, Charles P. Steinmetz, and R. H. Thurston.

Messrs. Burr and Morison are now out of the country, the one in Porto Rico, the other in Mexico; but they are expected to return in the latter part of April. We shall then endeavor to effect a prompt organization. Meantime, any suggestions that may come from interested correspondents in any department of engineering, and any statements of fact or reports of investigations in progress, will be welcomed and may be addressed to either member of the Committee on Engineering. They will be given careful consideration as soon as it proves practicable to take up the work.

Large as is the anticipated income of the Carnegie Institution, it is not at all improbable that it will be called for in full and, in any case, its expenditure will require very careful consideration. R. H. THURSTON.

ITHACA, N. Y., April 8, 1892.

I second Mr. Blackmore's motion that Professor Thurston be memorialized by the Society on the subject.

Mr. Blackmore: Let me say one more word. The scope of the Carnegie University at Washington is entirely for original research. It was Mr. Carnegie's intention, as I understood it, presented at the time, that any students who had taken their degrees from a university and desired to pursue their studies

further, this university was for that purpose, to give them the opportunity to pursue those original researches as far as they could possibly do it. Now how much more necessary is it for a graduate in any one of the engineering departments of the colleges to have this higher university to go to. There is not a branch of engineering to-day that is pursued as high as it can be pursued. There are mysteries that we do not realize, and they are not thought out and they are not worked out, simply because there is no higher engineering education in the strict sense of the word except as followed by engineers during practical experience. We have not yet developed anything like the point in mechanical engineering that we should do. There are so many questions in applied mechanics that we do not yet understand. It is of the highest importance that this matter should be brought home to this committee.

The President: Will Mr. Blackmore make his motion on paper, please?

Mr. Blackmore: I will give it to the stenographer. I would move that the Board of Governors be requested to prepare a petition to be presented to the Advisory Committee on Engineering of the Carnegie Institution, setting forth the importance of the establishment at the national capital of a laboratory for experimental appliances and for original research, and that one branch of such laboratory be devoted to the development of the art of heating, cooling and ventilation.

The motion was seconded by Mr. Kent, and caried.

Mr. Addams: That university, as I understand, is to be located in office buildings, that it is not to have any establishment at all.

Mr. Kent: I understand that is not settled yet.

Mr. Blackmore: As I understand this Carnegie grant, there is nothing definite. It is a university for original and higher research. If part of its researches can be carried on away out in Kalamazoo, Michigan, they will be carried on there. If it is necessary to arrange a laboratory to carry on special experiments, that can be done. The scope is not defined any more than that it is for original and higher research.

TOPIC NO. 4.

Concerning the Fulfillment of Contracts Containing a Clause Specifying Heating to 70° in Zero Weather.

Mr. Addams: There is a practical matter that can come up this evening. We have with us some visitors from Washington, one of whom has had peculiar experience in heating a Washington school building. I understand the contract amounted to $5,500. Apparently, all the requirements were complied with, still $3,000 is held up because there has been no zero weather in Washington since the apparatus was installed, to enable that contractor to test his apparatus at zero temperature and get this money. I wonder what we would do in a case of that kind as individuals, to demonstrate to the District Commissioners that the apparatus was adequate to accomplish the requirements of their specification.

Mr. Wolfe: There has been a decision by the Supreme Court of Missouri on the same question, and the judge ruled that they could not compel the owner to pay the money until they had zero weather to try. That is part of the contract.

The President: I think that is where the fault came in—it was in the original contract.

Mr. Blackmore: I believe I am the only member of the Committee on Standards here, and as it was part of our duty it is probably as well to make a report of progress. There is an attempt by this committee to formulate a code of tests that will determine an equivalent for zero weather. It is not a hard matter to formulate a code. It is a very difficult matter to prove such a code efficient—which must be done before it can be absolutely recommended to the Society as being something tangible to work by. Now the code has been presented to the members, and it rests with the members themselves to make tests during the coming season to see how near that code will be verified by actual practical experience. I trust the members will be interested enough in it during the coming winter to take the matter up, so that by January, when we have our annual meeting, something definite on the subject will be presented to the society. It is impossible for the committee to make the experiments necessary to determine the accuracy

of this code. It must be done by various members. Not one or two experiments can determine it, but if a dozen of the members of this society would undertake to test some apparatus that they have charge of between now and the first of January, they could present such results to the society, and if we could get a dozen of such tests they would very quickly tell whether this code that we have formulated is near enough for practical use or not. I trust each member will take this up seriously and make tests to verify the suggested code.

Mr. Sardou: In the city of Baltimore, there have been four school contracts let recently to Cook, Horner & Co., and under the specifications they will have ample opportunity to make tests such as Mr. Blackmore suggests. These schools will all be finished before the first of January, and in the specification was incorporated a clause which reads thus: "If zero weather is not to be had, the test can be made according to any of the present rules or standards used in such cases or such rules or standards that might come up in the future or before such tests are made." Now there is an ample opportunity. Cook, Horner & Co., or members of Cook, Horner & Co., are members of this association, and if the secretary or the proper officer will write to that concern, I think they can get the data from Cook, Horner & Co. before the first of January or about that time. These are all fan-steam heating jobs, hot blast and double duct.

Mr. Biggs: Mr. President, I am not a member of the association. May I be permitted to say a word? I happen to be the contractor for the job that Mr. Addams spoke of. The specification was a bad one, I admit. It had a clause in it requiring the apparatus to be tested to 72 degrees in zero weather. But we have zero weather there about two or three hours in the morning of three or four days in the winter probably. It was a fan system, a blower system. We tested the apparatus when the outside temperature was 32 degrees about, an average through the day of 32 degrees. We ran the inside temperature to about 88 degrees, which we considered satisfactory, and also the B. F. Sturtevant Company who put in the blower part of it, they considered it satisfactory. But the engineer did not know anything about it. The Superintendent of Construction did not know anything about it, and he ruled

that it was our duty to raise the temperature 72 degrees above the outside existing temperature. I told him that was impossible, and appealed to the commissioner. He asked me to get him the rule that would apply to this case. I looked around as far as I knew and made all the inquiries I could, and, as far as I can find out at least, there was no rule and I asked him to find out, and he was unable to do so. So the matter stands that we are held out of $3,000 of the contract price until such time as I suppose we shall have zero weather. That was the ruling at that time. Since that they have agreed to pay $2,000, but intend to hold $1,000 until they can have a zero test or some rule adopted whereby the test can be made. Mr. Blackmore asks for tests and that is the nearest thing I have had, and it was touched upon by Mr. Smith in his paper last month and he had a correct statement in that editorial.

Mr. Harvey: That puts me in mind of a case that I had once a good many years ago. I contracted to put an elevator into a large factory. The people that were starting the factory did not know exactly what they did want. They first wanted a hand-power elevator. Then they wanted that hand-power elevator made to run with power. We put it in. They hired some ignorant Polacks to hoist some timbers up to the top story; they put the timber on about four feet on each side wider than the platform of the elevator and then started the power. You can imagine the result, of course. The main gear broke above. Instead of their telling us about the elevator breaking, they went to another elevator builder and said: "If you go up there and condemn that elevator we will give you a contract to put in an elevator." Of course that was easily done, but it was going to take six weeks before he could get his elevator running, and by working a few hours overtime, we could get the other elevator running the next day. I said that I would not do it for the company, but I would do it for the contractor, that I would furnish the material necessary to start the elevator. After the elevator was running again I sued for my money. My attorney simply said to the judge that he must decide this one point: was that elevator Harvey's elevator or was it this company's elevator. If it was Harvey's elevator then they had no right whatever to use it. If it was the company's elevator then they must pay Mr. Harvey.

They could take either side of the horn they wanted. Now, in connection with that I should say that if this gentleman should wait till the fall of the year, until they required the heat, and he should simply say, if you don't want this apparatus, then it is mine and you must pay me for the use of it you have had, and I will take it out, there is no law could stop that, I think.

Secretary Mackay: I would like to ask Mr. Biggs if the law in the District of Columbia is not different from what it is in other sections of the country. I understand it is impossible to sue the commissioners there.

Mr. Biggs: I think that is true of all government work. I do not believe you can sue the government or take any such steps as the gentleman suggests. I neglected to state when I was talking before that carrying out that request of the engineer who requested me to raise the temperature—I did not try to do it, but to demonstrate to him that it could not be done I turned all the heat from this apparatus; it was an eight-room building—into one room, and the highest we could raise the temperature turned into one room was to 93 degrees. We raised it 5 degrees with all the heat turned into one room. I did that to demonstrate to him that it could not be raised very much higher. I did not think I could raise it that high, but I did raise it 5 degrees. That is as high as it would go.

Mr. Blackmore: How much was that above the, outside temperature?

Mr. Biggs: The average outside temperature was about 22 or 23, it was about 26 in the morning and about 40 in the afternoon. I got 88 all through the building, and with all the heat in one room I registered 93. I am not looking for information how to get out of it. I simply brought it up for discussion. There is no rule that will apply definitely now. Of course anything that could be said I should be glad to listen to.

Mr. Wolfe: The specification that you entered into specifies distinctly the boiler surface, radiation pipes, size of fan, and so forth?

Mr. Biggs: It does not specify the size of fan or size of heater. It does specify the size of boiler.

Mr. Wolfe: I guess you have got no way out of it.

Mr. Biggs: It is an arbitrary ruling. I don't know why

they did it. We heated another building exactly the same as this. It was accepted and passed about a month ahead of this. In that building, everything was specified and in this one it was not, and of course we had complied with the specification. The engineer and Superintendent of Construction does not know very much about the requirements. In the one building, the size of engine and fan and heater and tempering coils were all specified, and because he could say that we put in what was specified, he passed the building and we got our money for that, and they ran it all last winter and heated the building. In this one, because it was not specified, although we put in the same thing and he knew it, he could not state positively that the temperature clause in the specification had been complied with, he refused to pass the building.

Secretary Mackay: I would like to ask Mr. Biggs if the contract called for a test at that time, or that the apparatus should be of sufficient capacity to accomplish certain results.

Mr. Biggs: Of sufficient capacity to maintain a temperature of 72 degrees in zero weather.

Secretary Mackay: Your statement was, a short time ago, that you had to make a test of 72 degrees inside temperature and zero outside. Your contract then does not really call for a test in zero weather. It calls for an apparatus to be able to maintain a certain degree in zero weather.

Mr. Biggs: That is the idea.

TOPIC NO. 5.

Improving the Heating Capacity of a Radiator by the Use of an Electric Fan.

Mr. Broomell: I am sorry Professor Carpenter is not here to-night to read his paper on the operation of a fan system. It might possibly be of interest to state some little experience I have had on fan systems that are different from the ordinary fan systems. I think we all agree that we do not get the full efficiency of the direct radiators on account of the slowness with which the air flows over them. A great many radiators are so closely built that it is impossible for enough air to come in contact with the heating surface to get the best results. I have always been somewhat of a crank on experimenting. Two

winters ago I tried a little experiment at home. I took a little electric fan on a cold winter morning when my house was below the temperature that I guaranteed to heat it, and set it about 6 feet away from a direct water radiator. Within a few minutes after the fan was in operation I could feel a change in the temperature. The fan set up a rapid circulation of air over the radiator and all parts of the room soon had the same temperature. The room in which the fan was placed opened by folding doors into a large reception hall, but even under these conditions the temperature would run up several degrees in a very short time. I went a little further than that and constructed a little stationary fan behind that same radiator. I have not got that patented yet, but I hope to one of these days. With a very small motor entirely out of sight, I could throw that little fan on at any time and the radiator will do 20 or 25 per cent. more work than it ever did before. I once had a job of heating that gave a great deal of trouble. There was a bar room which did not come up to 70 degrees. They don't generally want to be very hot there but the owner would not pay. It was heated by overhead coils and after I had tried this little fan experiment of my own, I concluded to try it on the landlord. I had noticed an electric fan on a bracket near one end of the coil and I asked the old fellow if he had any objection to my running the fan, that I could heat the room and *ventilate* it at the same time. I made the air pass over that long row of coils. It acted like a charm. It was the cheapest thing I ever did in my life. Whenever he gets a little cold, on goes the fan and the room is heated and ventilated. [Laughter].

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INDEX TO VOL. VIII.